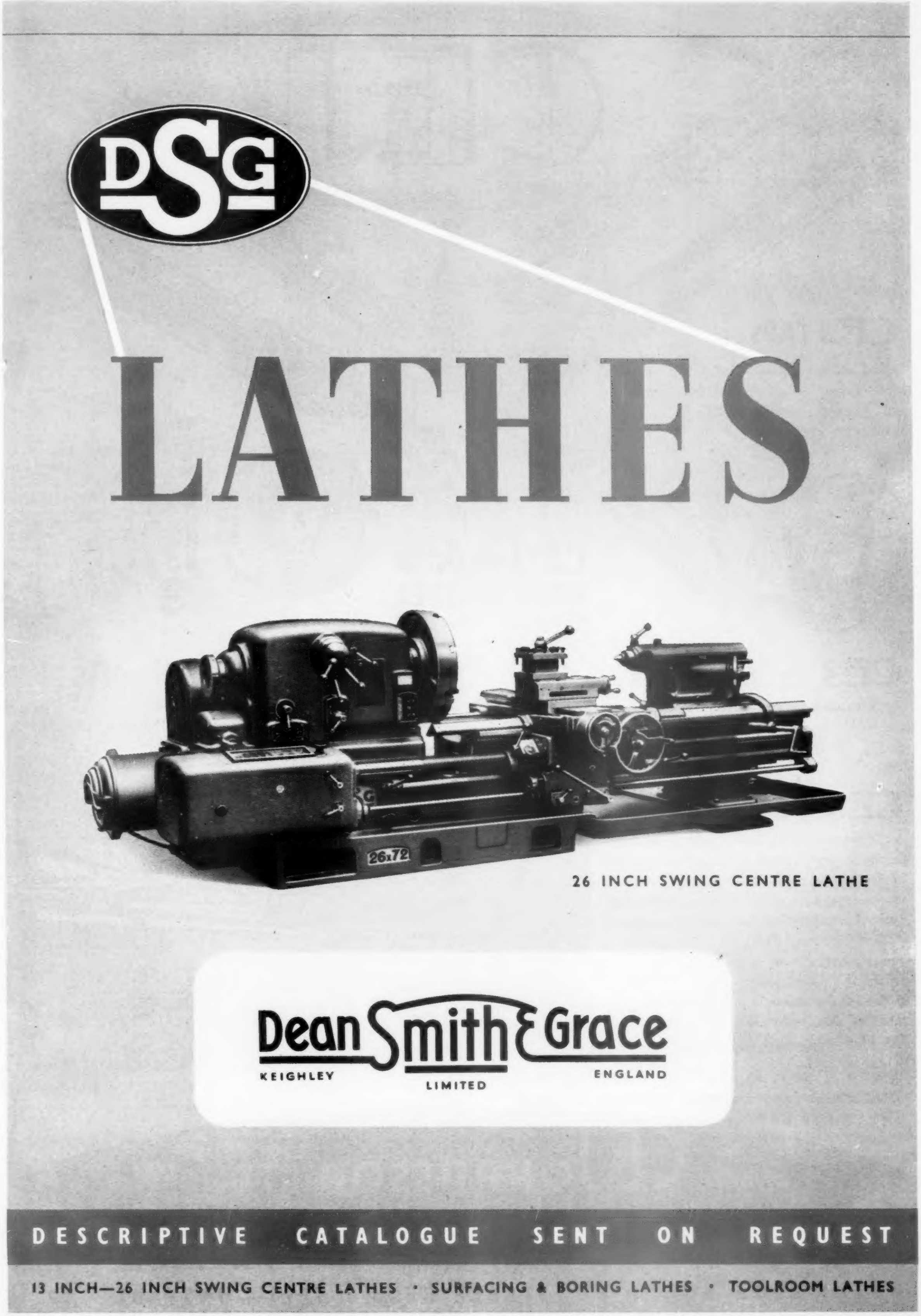
THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

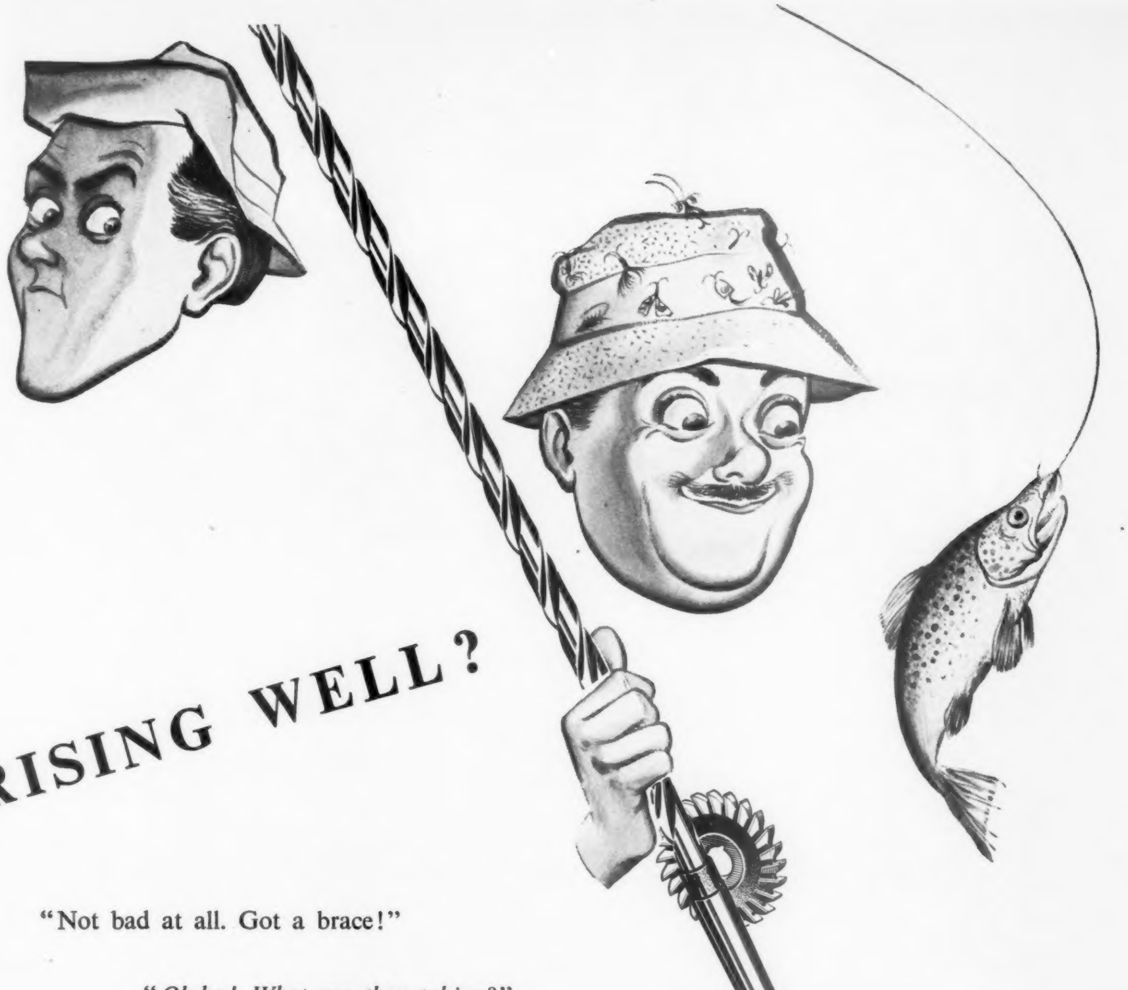
THE INSTITUTION OF
PRODUCTION ENGINEERS JOURNAL

36 PORTMAN SQUARE . LONDON . W1 Telephone: WELbeck 6813/7

Vol. 32, No. 12 *Price 10/-* *December 1953*

CONTENTS


DSG
LATHES
26x72
26 INCH SWING CENTRE LATHE
Dean Smith & Grace
KEIGHLEY
LIMITED
ENGLAND
DESCRIPTIVE CATALOGUE SENT ON REQUEST
13 INCH—26 INCH SWING CENTRE LATHES · SURFACING & BORING LATHES · TOOLROOM LATHES



RISING WELL?

"Not bad at all. Got a brace!"

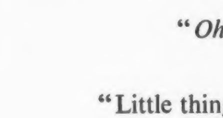
"*Oh ho! What are they taking?*"

"Little thing of my own—I call it 'Quicksilver Twist!'"

"*You've got M & C Service on your mind.*"

"Could well be—they'll rise to any occasion."

"*Back to the old subject—stand by to land.*"



BRITAIN'S FOREMOST DISTRIBUTORS

MONKS & CRANE LTD

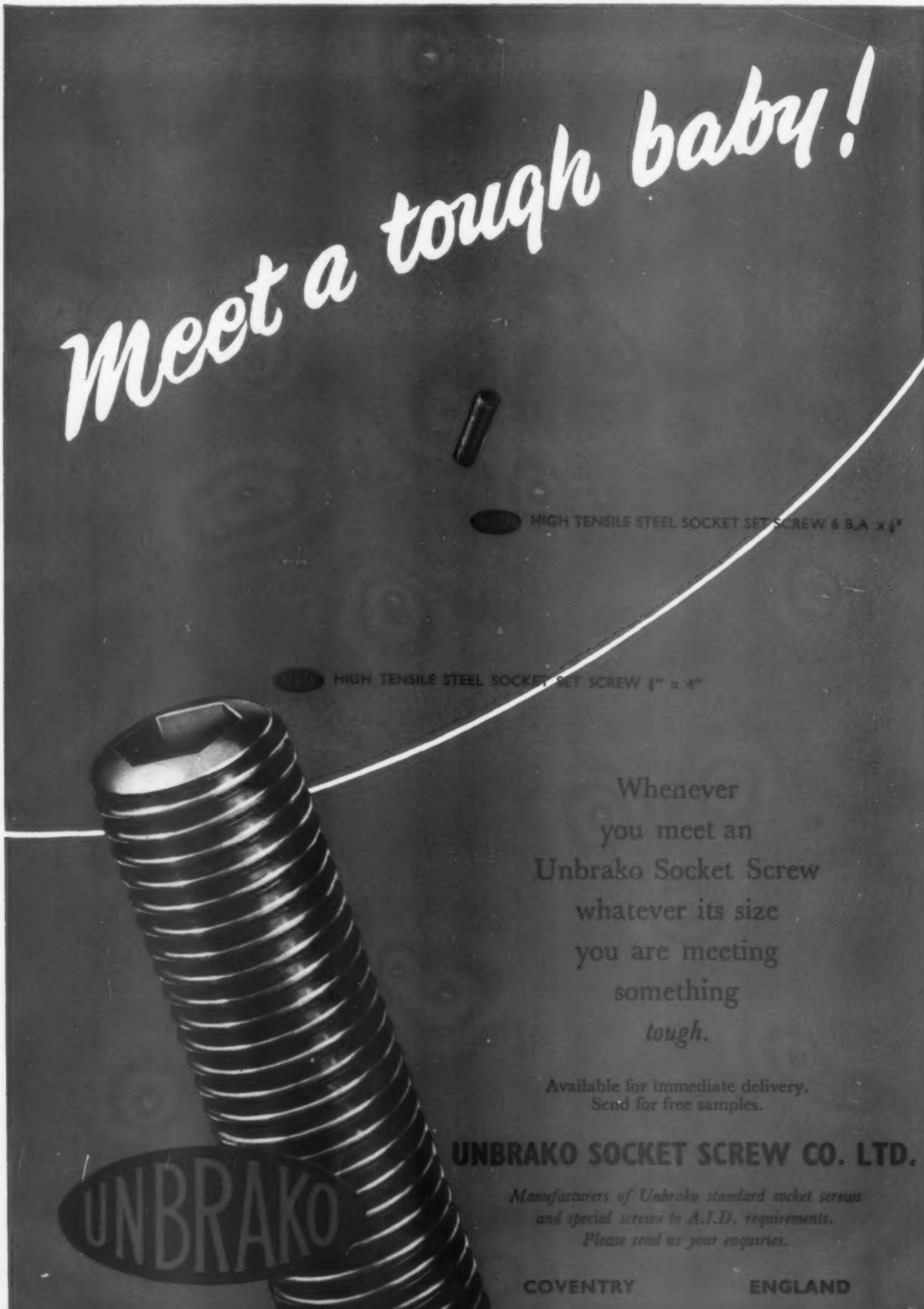
THE TWIST DRILL SPECIALISTS

HEAD OFFICE:
STANHOPE STREET · BIRMINGHAM 12 · *Tel: CALthorpe 1381 (5 lines)*

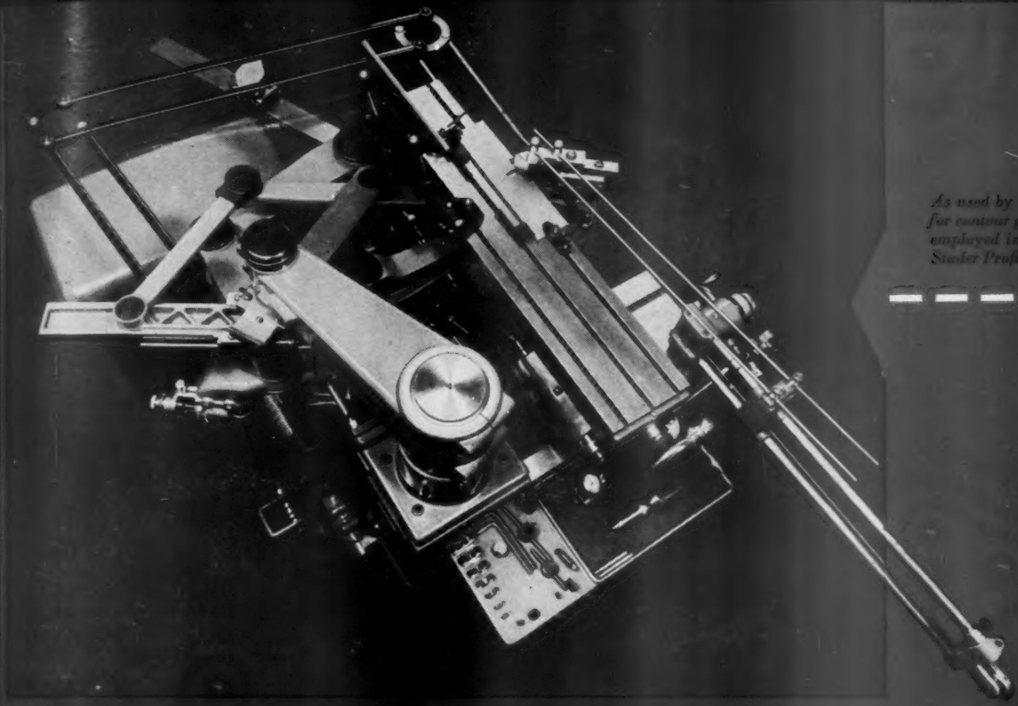
MANCHESTER OFFICE:
MANCHESTER OLD ROAD
RHODES, MANCHESTER
Tel: Middleton 3654 (3 lines)

LONDON OFFICE:
295 EUSTON ROAD
LONDON, N.W.1
Tel: EUSton 5311 (3 lines)

GLASGOW OFFICE:
79, CROWN STREET
GLASGOW, C.5
Tel: South 2907 (3 lines)


Meet a tough baby!
HIGH TENSILE STEEL SOCKET SET SCREW 6 B.A
HIGH TENSILE STEEL SOCKET SET SCREW
Whenever you meet an Unbrako Socket Screw whatever its size you are meeting something *tough*.
Available for immediate delivery.
Send for free samples.
UNBRAKO SOCKET SCREW CO. LTD.
Manufacturers of Unbrako standard socket screws and special screws to A.I.D. requirements.
Please send us your enquiries.
COVENTRY
ENGLAND
UNBRAKO


10% EXTRA OUT OF THE BLUE
"SPEEDICUT" DRILLS
FIRTH BROWN TOOLS LTD.
SPEEDICUT WORKS, CARLISLE STREET EAST,
SHEFFIELD, ENGLAND



As used by Messrs. Rolls Royce, Ltd., for contour grinding of tools and gauges employed in aero engine production — a Studer Profile Grinder Type P.S.M.130.

All contours in Tungsten Carbide

ground with ONE DIAMOND WHEEL SHAPE

STUDER CONTOUR GRINDERS

PSM 130 & PSM 250

The difficulty in grinding tungsten carbide to other than simple contours is well known. The Studer method makes it easy to grind any contour — makes it easier, in many cases, than in steel. Normal contours can, in fact be ground from the solid. It thus greatly extends the use of tungsten carbide for form tools, etc. Furthermore, there is an inbuilt quality in these Studer Grinders which is evident in the ultra-fine tolerances and ultra-fine finish obtainable consistently on standard Studer machines. Write for full details — or, better still, ask us to show you these machines in operation.

STUDER

AUTOMATIC OPERATION

Studer Contour Grinders produce all contours with a single wheel automatically controlled from a stylus acting on a template. The wheel is fed along the contour at a predetermined optimum rate, requiring no attention from the operator.

SOLE AGENTS FOR THE U.K. **SIDNEY JONES** PHONE: BATTERSEA 3246

SIDNEY G. JONES LTD., 8 BALHAM HILL, LONDON, S.W.12

The Institution of Production Engineers Journal
VOL. 32 NO. 12 DECEMBER, 1953

Education for Production Management and Production Technology

by H. H. BURNESS, C.B.E., M.C., Ph.D.
Assistant Secretary,
Further Education Branch, Ministry of Education.

In the second contribution to the series of articles on "Universals of Production", Dr. Burness stresses the vital need for co-operation between educationalists and industrialists.

The views expressed in the article are personal and not to be regarded as the official views of the Ministry of Education.

ONE of the most significant sentences in Professor Schell's article, "Balance of Effort", in the October issue of this Journal, is: "An increasingly large number of industrial problems call for ultimate decision by a mind which is facile both in technological and administrative areas."

Unfortunately, there has always been a tendency to separate the "technological" and "administrative" areas and even to assume that a mind facile in one area could not be facile in the other, because the mental qualities were different.

The dichotomy has been further emphasised by the separation of scientific and technological studies in Universities from the arts subjects, sometimes called the "humanities". Only in the Scottish Universities is a combination of mathematics and science subjects and the humanities encouraged. Many people still hold the view that a scientist cannot be an administrator or a humanist. Professor Schell's dictum is very much to the point when we are thinking of Production Management and it is essential that educationalists and industrialists should be ready to modify the traditional outlook.

It may be convenient to define the terms "Production", "Management" and "Technology", each of which can be defined in various ways, but for the purposes of this article it will be assumed that *Production* is the science and art of converting raw materials into articles of use to man; *Management* is the science and art of making the most efficient use of men and machines in production, that is, with the minimum of friction or wasted effort either among machines or among human beings; *Technology* is the science underlying the arts of Production and Management.

Before a useful product can be made, we must first think of the purpose, and then go through various stages. We must decide:

1. its purpose to meet a need of society;
2. the most suitable overall shape and characteristics;
3. the most suitable materials;
4. the sizes and shapes of the various parts to meet the forces which will act on them.

These are traditionally the *design* stages of the production function.

Then we have:

5. the choice of the various processes—manual, chemical, metallurgical, hand tool, machine tool —which will be used in the actual making of the article;
6. the planning of the works to house the various machines and other items of plant and the requisite labour force of all grades;
7. the training and supervision of the individual components of the labour force to ensure the most economic and frictionless working of men and machines.

These three are traditionally the production stages of the production function.

It is not proposed to deal with the distribution and selling of the article.

Note that the only thing of any importance is the article finally available — the "end product" All thought and labour involved are stages leading up to the final leaving of the production line. It is not unfair to say that design is the servant of production; too frequently has production been the slave of design. The ideal is that those responsible for design and those responsible for production should co-operate throughout all stages, from the conception of the product till it finally leaves the production line, and throughout all these stages they must both have in mind the end product and its usefulness and its convenience to the eventual user.

Traditionally in the engineering industry the only stages in the production function which merited the attention or interest of educated persons were the first four or design stages. Here was an opportunity to apply knowledge of the various sciences, mathematics, physics, chemistry and the slightly more mundane but still interesting sciences of strength of materials, theory of machines, theory of structures, thermodynamics, hydrodynamics, etc. All these sciences could be and ought to be applied in deciding on the shapes and sizes of the parts of the completed article.

But how were the raw materials to be given these various shapes and sizes and the necessary properties of strength, hardness, toughness, etc? The manager and the foreman would see to that and it was not necessary that they should be of any substantial intellectual calibre. No need for them to have a University or Technical College training—common sense was all they required and how they came by it no one knew or cared. And yet the cost of the final article depends at least as much on efficiency and economy in the production stages as in the design stages.

Present Position

Production Engineering

It is only in comparatively recent times that attention has been paid to the sciences of production as distinct from the sciences of design. It is true that for many years the City and Guilds of London Institute has been providing examinations in subjects such as machine shop engineering, foundry practice and other engineering skills. Most of these courses, however, are intended to be suitable for the highly skilled craftsman and not for the professional engineer or manager.

By 1939, a few Technical Colleges had introduced workshop technology into National Certificate courses with the approval of the professional Institution and the Board of Education, but such courses were looked on as a soft option for the weaker brethren who were unlikely to complete a Higher National Certificate course with the possibility of becoming professional engineers.

The wartime need to obtain the maximum rate of out-put produced a demand for training in the techniques of production and in 1942 the then Board of Education, in partnership with the Institutions of Mechanical and Production Engineers, instituted Higher Certificates in Production Engineering, which are awarded following a two-year part-time course of three evenings per week in which a selection of the following subjects is studied :

First year :

Properties and Strength of Materials	Jig and Tool Design
Metallurgy	Machine Tools
Theory of Machines	Metrology (Technical Measurement)

Second year :

Jig and Tool Design	Plastic Technology
Metrology (Technical Measurement)	Press Work—Plastics
Machine Tools	Welding Processes
Metallurgy	Hot Stamping and Forging
Press and Sheet Metal Work	Foundry Processes

A suggested third year or post-certificate course was proposed. This consists of :-

Motion and Time Study	Electro Technology
Production Control	Industrial Administration

It is noticeable that the only subjects in this course bearing titles similar to subjects in University engineering courses or National Certificate courses in Mechanical Engineering are Properties and Strength of Materials and Theory of Machines. It is a sad commentary on the attitude of those responsible for mechanical engineering curricula up to that time that this was, for all practical purposes, the first time that " production subjects " or " workshop technology " had appeared as a suitable curriculum at the " professional level ".

Of all candidates for Higher National Certificates in Engineering only some 5.9 per cent. have elected to take Production Engineering over the years 1942 - 1952, although the great majority of National Certificate holders are engaged in production rather than in design.

Generally speaking, the detailed syllabuses recommended in the Ministry's Notes for Guidance are entirely technological, although here and there is a mention of such subjects as Time and Motion Study, Wage Incentives, and Planning and Costing, which are certainly on the borderline between Management and Technology in the normally accepted senses.

It is just possible for a young man of above average intelligence to complete the course for the Higher National Certificate in Production Engineering by the age of 21, that is, when he normally finishes his apprenticeship, since the requirement for entry to the Higher National Certificate course is the holding of an Ordinary National Certificate, involving three years study from the age of 16 or some other equivalent qualification which, in general, would require a still longer period of study.

Management

For some years before 1939, a growing amount of interest had developed in educational circles regarding education for management. A number of specialist management bodies had been set up, each of them in

turn producing examination requirements for membership, for all of which the Technical and Commercial Colleges throughout the country were expected to prepare.

In 1945 the Minister of Education appointed a Committee with the following terms of reference :

" To advise the Minister of Education on educational facilities required for management in industry and commerce, with particular reference to the steps to be taken in regard to the organisation of studies, bearing in mind the various requirements of professional organisations and the need for their co-ordination."

Following this Report, the British Institute of Management and the Ministry of Education instituted a scheme for Intermediate Certificates and Final Diplomas in Management Studies :

1. An Intermediate course of instruction in the following subjects :

Part A.—Introductory Subjects
- 1. The evolution of modern industrial organisation.
- 2. The nature of management.

Part B.—" Background " Subjects
- 1. The economic aspects of industry and commerce.
- 2. The legal aspect of industry and commerce.
- 3. The psychological aspects of industry and commerce.

Part C.—" Tool " Subjects
- 1. Financial accounting and cost accounting.
- 2. Statistical methods.
- 3. Work measurement and incentives.
- 4. Office organisation and methods.

2. A course leading to the Final Diploma Examination for management in a specialised field consisting of the following subjects :-

(1)–(6) Syllabuses prescribed by the appropriate Management Professional Institution.
(7) Management — Principles.
(8) Management — Practice.

3. A course leading to the Final Examination in general management consisting of the following subjects :-

(1) Factory Management.
(2) Distribution.
(3) Development and Design.
(4) Purchasing, Storekeeping and Transportation.
(5) Personnel Management.
(6) Higher Business Control.
(7) Management — Principles.
(8) Management — Practice.

Note that the certificates and diplomas are in Management Studies and not in Management. This is to avoid any suggestion that attendance at a course of instruction in a College and the holding of a certificate makes a man a " Manager ". Seventy-two Technical Colleges have been approved for Certificate courses and thirty-six have been approved for Diploma courses.

It will probably be accepted that a Production Manager, if he is to have a mind facile both in technological and in administrative areas, ought to have amassed most of the knowledge outlined in these curricula of production technology and management studies before he can effectively assume major responsibility. What proportion of this knowledge should be obtained in the educational system either by full-time or part-time courses, and what proportion can be obtained by experience in and on the job and by private reading, attendance at meetings of professional institutions, discussions with colleagues, and so on, will always be a subject of argument, but the demand for courses of instruction, particularly in management, indicates a definite change in attitude of both the young men and their employers towards appreciating the value of educational courses in these subjects.

Both the courses in Production Engineering and in Management are organised on a part-time basis and in almost every case for evening classes. Owing to the age of the students concerned—twenty to twenty-five or thirty—neither the men themselves nor their employers look on part-time day release with favour.

Attempts to organise full-time courses in these subjects have met with very little success. The reasons for this appear to be :

(a) young men and their parents and schoolmasters see no value in a full-time course of education unless it leads to a popularly accepted qualification such as a University degree;
(b) employers are of the same opinion;
(c) employers and many educationalists believe that the subjects included in these courses can only be taught, if at all, to persons who have either already had or are simultaneously obtaining industrial experience and seeing the application of the principles taught.

With one or possibly two notable exceptions, no University engineering school in this country pays any serious attention at the undergraduate level to subjects in the production or management fields.

We in this country are justifiably very proud of our system of part-time technical education, which for generations has given an opportunity to qualify for the highest posts to young persons entering industry at an early age and frequently at a relatively low educational level.

The very success of the system has tended to over-emphasise the advantages of simultaneous industrial experience and technical education. There is no doubt that the combination has very many good points, but it is not always realised that its success has been largely due to the fact that a relatively small proportion of the population had the opportunity of full-time education—at a University or elsewhere—up to the age of 21 or 22 or, in fact, beyond the age of fourteen. Industry could therefore rely on obtaining a good proportion of the more intelligent individuals at the normal recruiting age of fourteen (or younger at an earlier date). These then found their way by hard work and " night classes " to responsible positions.

The Future

Now that a much higher proportion of young persons have opportunities of prolonged full-time education, it would seem reasonable to enquire whether the vocational education provided by the Universities for a relatively small number of professions should not be broadened, so that full-time courses suitable for production engineers and managers might be provided as well as courses for lawyers, doctors, physicists, chemists, etc.

In considering any new courses of this level we are always faced with the difficulty of ensuring that the disciplines are comparable with traditional courses and that they are equally like to produce " the full man ". Whether a subject satisfies these conditions or not depends not so much on the content of the subject as on the way it is taught, and on how it is shown to be related to other subjects in the course and to the general corpus of knowledge on which human beings can base their behaviour.

If this is so can we be satisfied with the present position? Surely it should be possible to build up a full-time course of full University standard and fulfilling the above conditions from the material forming the syllabuses in the courses in Production Engineering and Management outlined earlier in this article. The former may be looked on as new technologies or new applications of science and the latter as new humanities, since they deal very largely with human relations in the industrialised world of to-day.

Such a course would contain elements from both groups and so combine science and technology with humanities, a feat which so far seems to have eluded the educationalists in this country but has, in fact, been accomplished in just this way in at least one other country.

Have we not reached the position when at least one Institution of higher learning could be induced to make the experiment of providing full-time and/or sandwich courses on these lines at both undergraduate and post-graduate levels and, of course, encourage both post-graduate students and staff to engage in research work without which no teaching establishment can hope to be really successful? This would appear to follow traditional practice.

Special measures would no doubt be required in the first place to obtain suitable fully qualified staff. One—but only one—of the primary functions of such an establishment would be to provide from among its students a proportion who would, after appropriate experience, proceed to teach in other establishments throughout the country.

It is, of course, realised that the educational or training period of a production manager is not a matter of three or four years in a College but his training and education is, in fact, a continuous process up to and beyond the age—say thirty—at which the first really responsible position is likely to be obtained.

What is suggested here is that sometime during this training period an educational course of the type outlined might be provided. There is much to be said for a period of employment between leaving school and before entering an undergraduate course and a further period of employment followed by a post-graduate course, particularly for those who are likely to reach the highest management grades. Industry must, of course, play a full part in the training by seeing that the individual is given satisfactory experience.

The most important step is for industrialists—technologists and management—and educationalists to co-operate in producing a flexible scheme, which will give production management its rightful place as a profession for which a high standard of knowledge and educational attainment is appropriate, so attracting a due share of the best brains of the country at an early age as a major factor in increasing industrial productivity.

THE FUNCTION OF LUBRICANTS AND PROCESS OILS IN STEEL AND TINPLATE WORKS

by W. WILLIAMS, A.M.I.Mech.E., A.M.I.Prod.E.

Presented to the West Wales Section of the Institution, 6th March, 1953.

Mr. W. Williams

Mr. Williams, who is Senior Engineer of the Vacuum Oil Company, Ltd., Cardiff, was until 1942 engaged in the steel and tinplate industry in various capacities.

At the time of joining the Royal Air Force, in which he served as Air Navigator (B) and Bombing Instructor, he held an executive appointment in an old style tinplate works. He joined the Vacuum Oil Company in 1947 and was appointed to his present position in 1949.

Mr. Williams is a member of the West Wales Section Committee.

THE very rapid development which has taken place in the steel and tinplate industry in South Wales concerns all those present so intimately that it is well to look into one of the important factors relating to this development: that is, lubrication.

It is impossible in the space of one Paper to go fully into the subject of sheet and tinplate mill lubrication. Therefore, except in one or two instances, a detailed study of individual aspects has been deliberately omitted. In the past, from the production standpoint, lubrication played a relatively unimportant part. Today, the very high operating speeds and outputs are in part a direct result of developments which have taken place in the field of lubrication. Gone are the days when to think of lubricating a unit of machinery suggested pouring oil out of an oil-can.

OLD TYPE HAND MILLS

Hot Neck Lubrication

In the old type hand mills, so familiar to most present, lubrication was, and still is, of a comparatively rough nature (Fig. 1). This, of course, refers to lubrication of mill necks and does not include prime movers. Hot neck lubrication is carried out almost entirely with the use of a bitumen base material. The bearings are of the half phosphor-bronze open type.

In Fig. 2, it can be seen that the arc of contact is very small, and the full rolling load has to be carried on this together with all the thrust if the mill happens to be out of line.

Roll body temperatures are approximately 450°C. As the rolls are seldom more than 36″ wide, neck temperatures approach body temperatures by conduction. The rolls are ground concave so that when working heat is reached, they are theoretically parallel. The high neck temperatures, which may be above 300°C., make lubrication difficult. In the past, a bitumen base grease has proved relatively satisfactory. Improvements in lubrication have been obtained by re-using the grease. When first applied to the mill, the volatiles are driven off and the remaining grease, on being re-used, has a higher drop point.

One of the biggest causes of heavy brass wear is that the radii become dry, thus allowing metal-to-metal contact. This results in cracking of the bearings and heat-crazed roll necks. The average life of a bottom bearing is in the region of 500-600 tons. Very little progress has been made in this form of lubrication from that which was common practice 20 or 30 years ago. In works where the mill grease is re-boiled and purified, a much lower consumption of grease is possible. Hot neck grease consumption varies between 4 and 9 ozs. per box of tinplates.

Cold Rolling

In the old type cold rolling (Fig. 3), whether for sheet or tinplate, neck bearing pressures are very high, thus making bearing lubrication difficult. However, provided a suitable lubricant is used, neck temperatures can be kept down to below 220°F. and

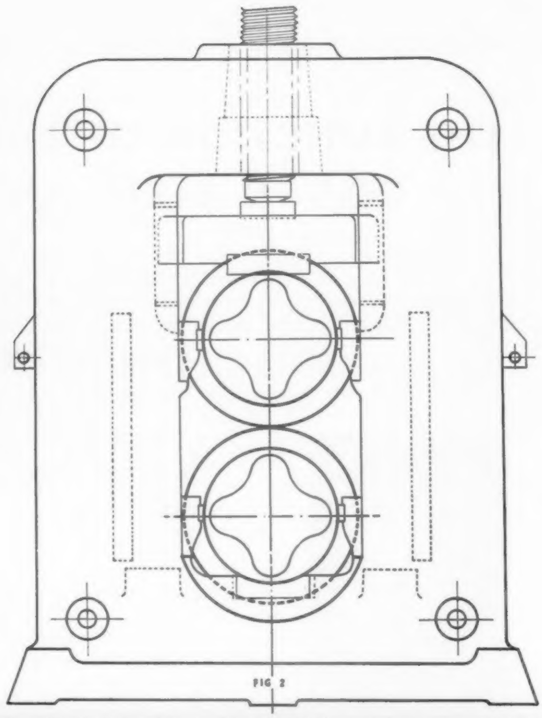


Fig. 1 (above). Old type hot mill — rolling.

Fig. 2 (right). Old type hot mill — drawing of standard and assembly.

Fig. 3 (below). Old type cold rolls.

Fig. 4. Mardy Tinplate Works.

roll shapes can thus be controlled with reasonable accuracy. The grease used for this kind of application has of necessity to contain extreme pressure additives, and, as happens in any plant which is hand lubricated, boundary lubrication is general. The additives in the grease under such conditions function as anti-welding agents and prevent scoring of the bearings. In a few instances, mechanical grease lubricators have been successfully used.

Rolling Medium

In most of the old type mills, rolling is carried out dry, i.e. there is no application of lubricant to the roll body. It is true that, in some sheet works, water is run on to the roll body when rolling some hard alloys, but as a rule speeds are low and, therefore, the use of a lubricant is not necessary. Figs. 4 and 5 show the layout of the hot mills at two very well-known tinplate works, i.e. Mardy Works, Gorseinon, and King's Dock Works, Swansea.

MECHANICAL MILLS

In order to speed up production and to minimise the amount of manual operations, mechanical mills were developed. In these, the bars and sheets to be rolled are conveyed through the furnaces either by means of a walking beam or roller chains. This has speeded up production to approximately five times that obtained in the old hand mills, and instances are on record where tonnage rolled is in excess even of this. Whereas in the old type hand mills the breaking down of the bars occurred in the roughing rolls, in the mechanical mills the breaking down is usually carried out on a 3-Hi mill. As a rule, bearings on this type of mill are of fabric and the only lubricant necessary, is water, although soluble oil is more satisfactory because it gives protection against corrosion.

Life of these bearings is further improved if they are given a periodic application of grease, particularly when closing down and starting up. The grease prevents scoring of the bearings when under heavy start-up loads. Whatever lubricant is used must be applied in adequate quantities, because of the low thermal conductivity of fabric bearings and their inability to stand high temperatures.

It has been found in practice that the life of these bearings varies considerably, but if adequate clean water is used a life of 8,000 tons or more can be expected for the bottom bearings. After removal, the bearings will have a further useful life of several

thousand tons as top roll bearings. If the water is not circulatory and is used for subsequent processes, such as pickling, great care has to be exercised if grease is used. Over-application would mean contamination of the water with resultant trouble further down the line. If, on the other hand, the system can be made self-contained a soluble oil emulsion will prove more satisfactory than clean water.

The pack mills operate under high temperatures and a severe load is placed on roll neck bearings and mechanical heaver-overs because, when rolling alloy steels, particularly Stalloy, heat convection is very high. A very efficient grease block has been evolved for lubricating the roll necks of hot sheet mills. This is made from approximately 85% of mill returns and 15% of new grease. Roll neck temperatures are usually maintained at 210-230°C., thus they are relatively easier to lubricate than tinplate mills. Reclaiming used grease can effect the same saving here as that mentioned under hand mills. The procedure is to reboil approximately 85% of old grease removed from the mill and which has become oxidised. To this is added about 5% of a base bitumen and 10% of an E.P. type grease. Great care must be taken that the grease boiler temperature is sufficiently high to allow for complete mixing of the old and the new greases, because of their very different drop points. New grease has a drop point of about 200°F., therefore, it could not be used at the mill in the new condition because of the high neck temperatures. The exact proportions of the old and new greases used in making the grease blocks are arrived at by experimenting, as the degree of carbonisation of the old grease varies not only with the number of times it has been re-boiled, but also with the mill on which it was used. For example, returns from a Stalloy mill are much drier than returns from a mill rolling car body sheets. It is of advantage to have the grease boiler in two sections, the grease on boiling flowing over a weir into a cooling compartment. It thus leaves behind all contaminants, such as mill scale, which settle to the bottom of the boiler compartment and can be removed at week-ends.

With careful adjustment, a grease can be made having a drop point which is only slightly below the roll neck temperatures. The boiled grease is either run out on to the floor and then cut up into blocks of approximately 3" x 3" x 6", or is run into moulds of approximately the same size.

Fig. 5. King's Dock Tinplate Works.

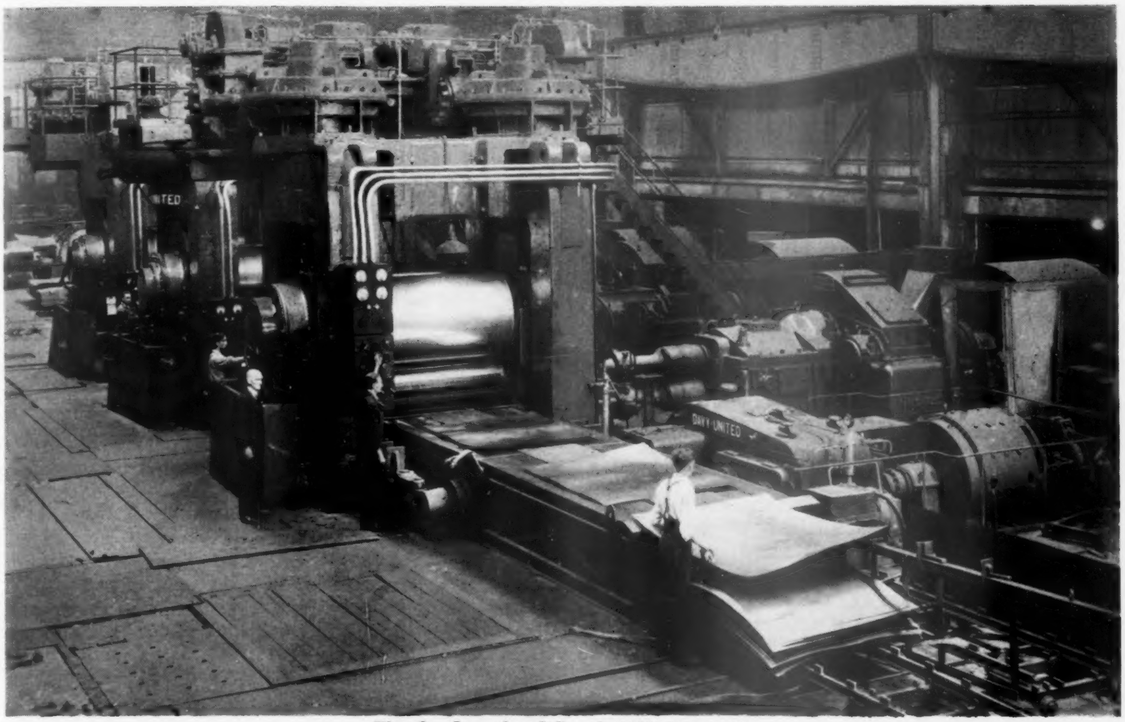


Fig. 6. Lysaghts 3-Stand 4-Hi piece mill.

The mechanical furnaces present several problems because of the high temperatures. Whatever lubricant is used must be capable of being burnt off without leaving a heavy residue. In cold rolling, white metal bearings are used and these are usually lubricated by means of a soft grease applied through a mechanical lubricator.

In the rolling of car body sheets, a 3-stand 4-Hi mill (Fig. 6) was formerly used and this method of rolling is more or less half-way between the old type of cold rolling and the modern continuous cold reduction mill. The demand for greater production, improved quality, reduction of scrap and reduced manpower has resulted in the evolution of the modern mill.

MODERN MILLS

Hot Line

The modern type continuous mill is well-known and the illustrations (Figs 7 to 10) are of one which has given, and is still giving, a wonderful performance, i.e. the hot line at Ebbw Vale. At times the output has been almost twice that for which the mill was designed. One thing becomes obvious; as the continuous mills have to keep in operation almost without a stop from Monday to Saturday, some automatic means of lubricating all bearings and gears is essential. The type of mill neck bearing lubrication varies according to the mills. For example, in the slabbing mills (Figs. 7 and 8), the bearings may be of fabric and may only require water or soluble oil as a lubricant. The use of fabric bearings is still in the experimental stage at this particular mill. The final roughing stands and finishing stands (Fig. 9) have roller bearings for back-ups and also for the work rolls. With the use of these bearings in the hot line, the old disadvantage of difficulty of lubrication disappears, because the neck temperatures never rise more than, at the very outside, 150°F. Operating at these relatively low temperatures affects production in two ways—higher speeds are possible and work roll shapes can be kept to a very close tolerance. Because of this, the shape of the strip being rolled can be closely controlled.

Cold Reduction Mills

Cold reduction mills usually are of 3, 4 or 5 stand 4-Hi tandem construction. When it is required to roll down to car body gauges, it is usual to do so in a 3 or 4 stand 4-Hi tandem mill, but when tinplate gauges are to be rolled, it is necessary to use a 5-stand 4-Hi tandem mill, such as shown in Figs. 10(a) and 10(b).

ROLL NECK LUBRICATION

One of the most important factors in the efficient operation of the high speed mills is roll neck lubrication. It is a problem which requires very close attention. As the mills have developed in speed and capacity, so has it been necessary to improve lubrication. It is true to say that if advances had not been made in roll neck lubrication, the present high rolling speeds would not be possible. Modern roll neck bearings are generally of two types, flood lubricated and operating under circulatory system, and roller bearings operating on an all-loss system.

Flood Lubricated Bearing

This is a totally enclosed oil film bearing whose inner and outer races are separated by an unbroken oil film. It was developed for use on roll necks in rolling mills in order to counteract fatigue and wear. It is normally loaded to 3,000 p.s.i. and for, say, 9″ diameter rolls, it would carry a load of 100,000 lbs. and for 56″ diameter rolls, 5,250,000 lbs. For rolls bigger than 21″ in diameter, a roll thrust race is incorporated in the bearing. Oil enters the bearing through a drilled hole parallel to the axis of the roll and at any convenient location in the chock. The drilled hole meets two annular grooves in the bore of the chock extending over 180° around the bore. Horizontal branches from these annular grooves on the horizontal centre line of the bearing on each side of the bore of the chock carry the oil to holes in the side of the bushing, through which the oil flows to oil pockets in the bore of the bushing, one on each side centred on the horizontal centre line. These oil pockets are eccentric re-bores which extend almost to the inboard and outboard ends of the bushing. From these oil pockets, which are kept full of oil under slight pressure, the bearing receives its oil supply, the sleeve acting like the rotor of a pump and pulling a wedge-shape film of oil into the load zone of the bearing. As there is an oil pocket on each side, it does not make any difference which way the bearing rotates.

The oil is retained in the bearings by seals at both inboard and outboard ends. The inboard seal is a double seal, whose element facing the roll barrel is used to prevent the entrance of foreign matter to the bearings. As a further guard against this eventuality, a ring of bronze is held against the roll barrel under light spring pressure, and water and other foreign matter are prevented from by-passing around this ring by a flexible leather boot. On mills where a rolling oil or water is used, it is usual to install inboard water shields made of sheet metal, to deflect the sprays and prevent them from impinging on the bronze ring of the water seal assembly. Flood lubricated bearings have a very low co-efficient of friction, somewhere in the range of .0012 to .003, which is comparable to the co-efficient of friction of roller bearings.

The lubricant supplied to a bearing of this kind must be a high grade mineral oil free from all impurities, and must have a high resistance to oxidation, so as to prevent the formation of sludge when subjected to hard service. It must separate rapidly from water, and have a high viscosity index. Although provision is made for the close control of the temperature of the oil, a rise of 30°F. is quite usual in the passage of the oil through the bearing.

For arriving at the viscosity of oil to be used, an empirical formula is employed to draw up a graph showing the relationship between the co-efficient of friction and $\frac{ZN}{P}$, where Z is oil viscosity, P is unit bearing pressure and N is r.p.m. A typical graph is shown in Fig. 11(a). It will be seen that the value of $\frac{ZN}{P}$, which corresponds to the minimum value of the co-efficient of friction, is a critical one. Below this, a full fluid film will not be provided, therefore, boundary lubrication will result. The film strength of the oil is, therefore, of considerable importance, particularly in starting and stopping. If it is assumed that a bearing loading of 3,000 p.s.i. is used, the

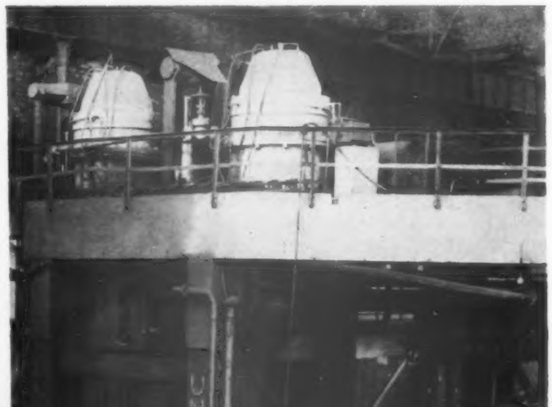



Fig. 7. Ebbw Vale Blooming Mill—unrolled ingot.

following table gives the required minimum r.p.m. for continuous load carrying capacity :—

Min R.P.M.	*Corresponding Minimum Viscosity SSU Per Full Rated Load.*
11	2,400
12	2,200
15	1,800
23	1,200
31	900
37	750
53	500

The condition of maximum load, maximum speed and minimum viscosity of oil that will support the load will result in the lowest possible co-efficient of friction. It will be seen from this that, theoretically, a different viscosity oil is required for each stand of a multi-stand mill. As Stand No. 5, for instance, rotates at a much higher speed than Stand No. 1, a lighter oil is required if friction is to be kept to a minimum. This is not practicable, as it would be exceedingly costly, because it would necessitate a complete circulation system for each Stand. A compromise is, therefore, arrived at and two separate systems only are usually used to cater for the five Stands. The oil used for the first two Stands is heavier in viscosity than that used for the final Stands.

The quantity of oil required to lubricate the bearing is based on the complete replacement of the oil film in a specified number of revolutions. This means that a given bearing operating at high speeds needs more oil than the same bearing operating at low speed. Oil factors have been developed for each size bearing which, when multiplied by the maximum r.p.m. of the roll to which the bearing is applied, gives the maximum g.p.m. of oil required. The basis on which the oil factors are arrived at is partly theoretical and partly empirical, and the use of the oil factors always results in an oversupply of oil or what is termed "flood lubrication". This type of lubrication not only gives the bearing an adequate oil supply, but keeps it clean and results in uniform bearing and neck temperatures, which property is highly desirable in rolling accurate products.

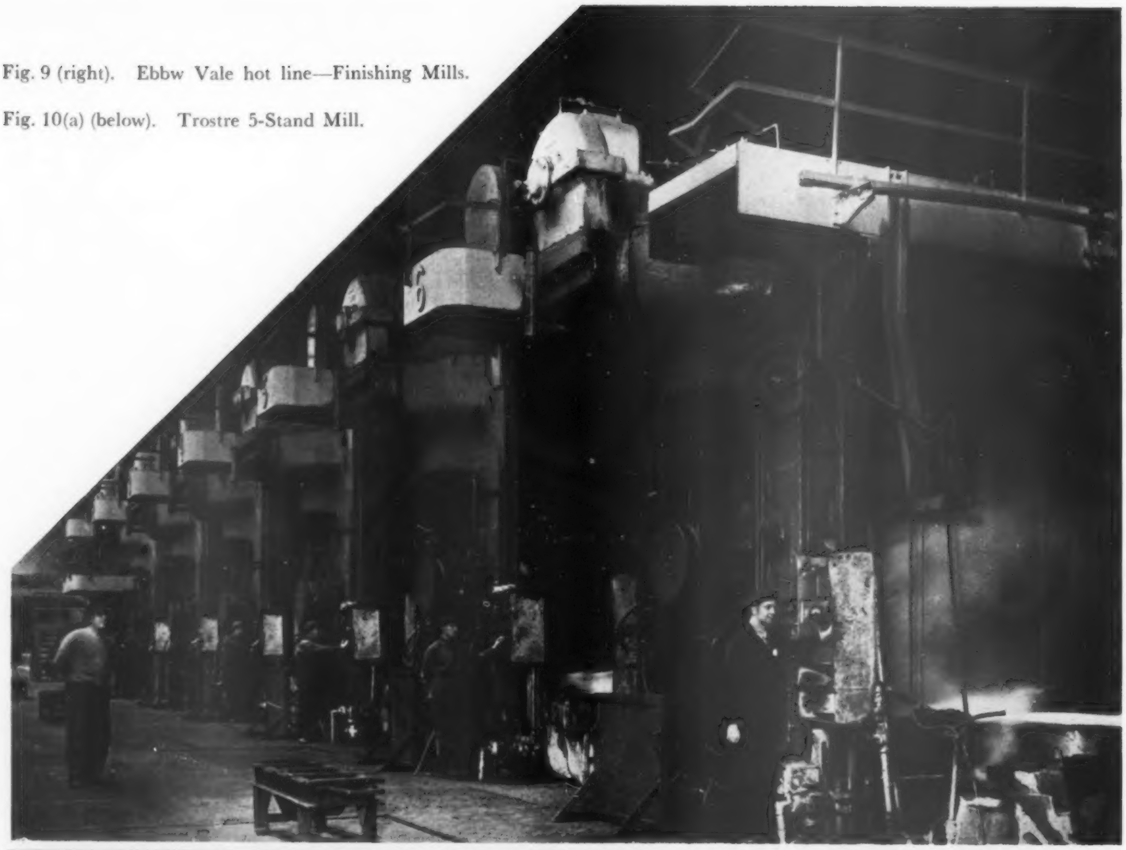
It is usual to fit a thermometer on the oil supply risers and at the top of each supply riser is a pressure gauge, which enables the operator to know definitely that the oil is being supplied to the bearing at the correct pressure. There is also a pressure switch located at the same point, with a low limit alarm and red light. The low limit is set at a pressure below the normal operating pressure at the particular mill stand and if the pressure drops below standard, the red light goes on, signalling the operator; it is usual to connect the red light circuit to a siren. In a multi-stand mill, the lighting of any red light will sound the siren and then by looking down the line of stands, an operator can tell just where the pressure is low and make the necessary investigation and correction.

Sufficient pressure is carried on the riser at the mill stand to cause the required volume of oil to flow through the bearings when the mill is operating at top speed. At any speed below the maximum, the bearing acts as a measuring valve, to the extent that it actually takes less oil when running at slower speeds. At half speed, a bearing may take 60 or 70% of the oil that it takes at top speed. When the mill slows down the pressure tends to rise, but this is limited by pressure regulating devices in the supply line

Fig. 8. Ebbw Vale Blooming Mill—partly rolled ingot.

Fig. 9 (right). Ebbw Vale hot line—Finishing Mills.

Fig. 10(a) (below). Trostre 5-Stand Mill.



which prevent any appreciable fluctuation of pressure. At the point where the flexible supply line is connected to the chock, nozzles are used to determine the amount of oil which will flow into the bearing, the flow being governed by pressure on the supply line ahead of the nozzle. Pressures used in the supply risers and the flexible supply lines are usually from 5 to 15 p.s.i.

OIL CIRCULATING SYSTEMS

There are almost as many different types of circulating systems as there are mills. Figs. 11(b) and (c) show the system used at the 5-Stand mill at one of the most modern works in the world, at Trostre. The five stands are supplied by two systems, one covering Stands Nos. 1 and 2, and the other covering Stands 3, 4, and 5. The two tanks for Stands Nos. 1 and 2 contain 4,000 gallons each of an oil of viscosity 1,650 secs. Saybolt, and the oil is circulated by two pumps each capable of delivering 90 g.p.m. One of these pumps is running continuously, and the other is a stand-by. Auto-Kleen filters, capable of handling 100 g.p.m., are fitted in the delivery side of the pumps. The filter size is .008″. The scrapers on these filters are operated as required. If there is a pressure difference of 8 lbs. an alarm sounds. The pressure vessel has three pressure gauges, one operating the low pressure howler, one for the second pump, and the other to indicate actual pressure. The above gauges are set to pre-determined limits and if the pressure drops below the low gauge pressure, the alarm rings and the second delivery pump goes in. If

Fig. 10(b). Troste 5-Stand mill in operation.

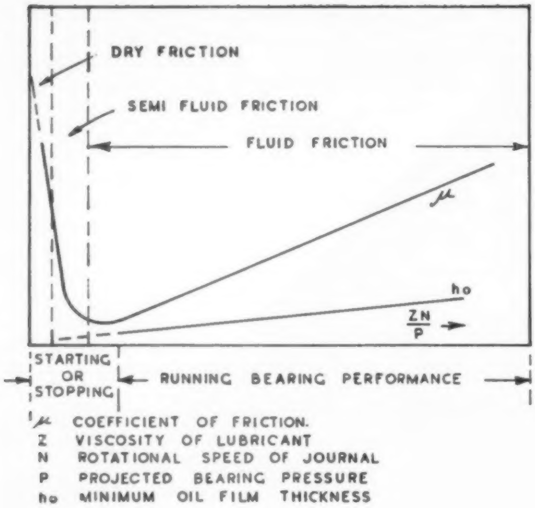
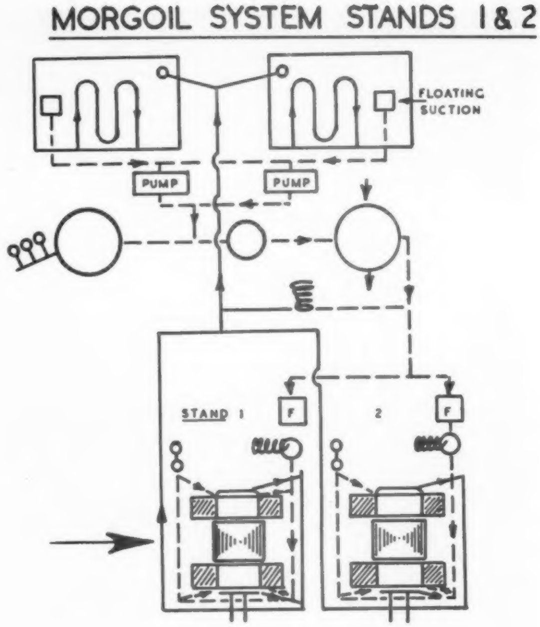
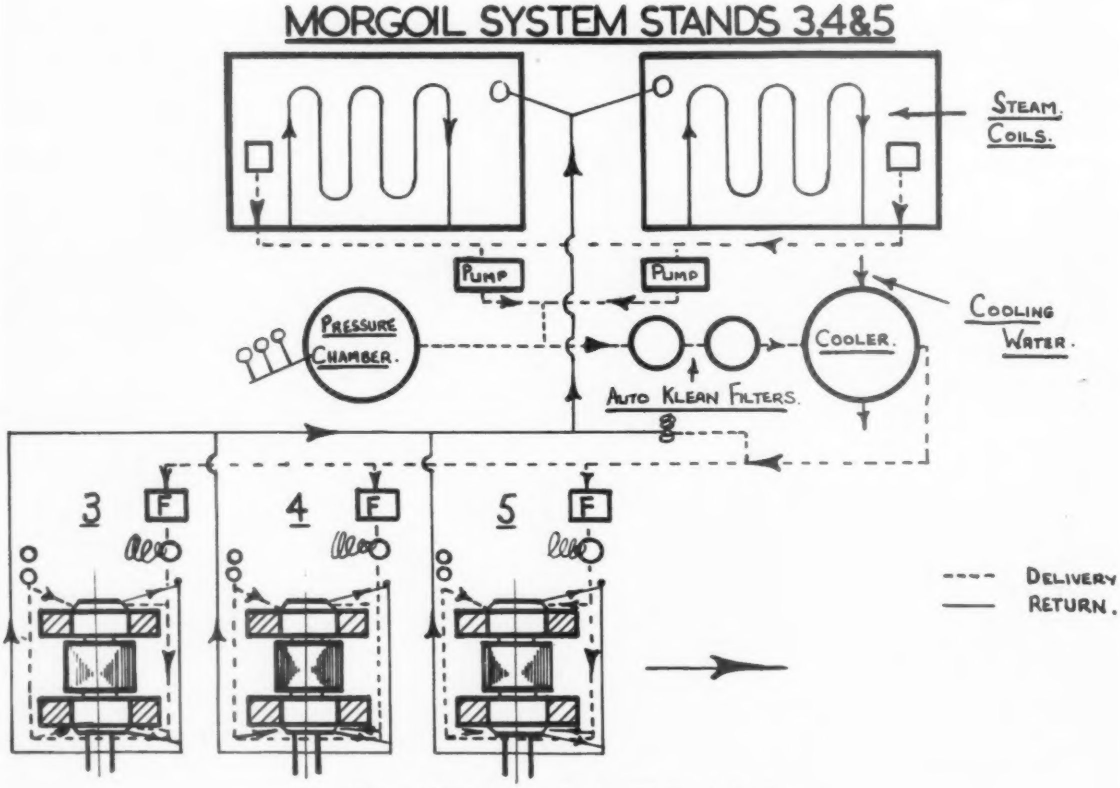


Fig. 11(a). $\frac{ZN}{P}$ Graph.





Figs. 11(b) and 11(c). Trostre Bearing Oil Circulation System.

DETAILS OF LUBRICATION SYSTEMS
TROSTRE 5 STAND MILL

	G.P.M. REQD	VISC S.S.U/100°F.	TANK CAPACITIES	PUMPS G.P.M.	PUMPS PRESS.	COOLERS TEMP. DROP	COOLERS G.P.M WATER 80°F	GRADE OF OIL
MORGOIL 1 & 2	73	1600/1700	2 X 4000G	90	60p.s.i.	140° 90°	150	
MORGOIL 3, 4 & 5	247	800/900	2 X 14000	300	60p.s.i.	165° 90°	830	
PINIONS & SCREWDOWNS	130	2300	6000	140	60p.s.i.	140° 90°	270	

CALIBRATION OF MORGOIL BEARINGS
OIL IN G.P.M

STANDS	TOP DRIVE SIDE	BOTTOM DRIVE SIDE	TOP OPERATING SIDE	BOTTOM OPERATING SIDE	TOP THRUST	BOTTOM THRUST	PRESS	TEMP °F	FEET/MIN	R.P.M
1	6·5	7	7	7	1·25	1·25	12p.s.i.	90	375/1200	65/220
2	10·5	10·5	10	11	1·25	1·25	12p.s.i.	90	605/1512	110/275
3	10	10	10	11	1·25	1·25	12p.s.i.	90	1100/2089	200/380
4	18	18	18	20	1·25	1·25	12p.s.i.	90	1649/3189	300/580
5	25	25	25	24	1·25	1·25	12p.s.i.	90	2475/4453	450/810

Fig. 12. Lubrication Systems and Calibrations—5-Stand Mill.

both pumps running together cannot raise the required pressure in 20 seconds, the mill will automatically shut down.

A cooler is used to control the temperature of the oil going to the mill. The oil is heated above the working temperature by means of steam coils and cooled to the desired temperature. It has been found that, by adopting this method, a more accurately controlled working temperature is obtained. The cooler reduces the temperature of the oil from approximately 140°F. to 90°F.

To overcome any pressure difference across the filter a relief valve is fitted. At the end of each delivery line a temperature and pressure indicator is fitted, to record minimum pressure and temperature in the four bearings served. If the pressure falls below the pre-determined level (10 p.s.i.) on any stand, a klaxon will sound. The tanks serving Stands 3, 4 and 5 are of 14,000 gallon capacity each and the oil viscosity is 1,100 secs. Saybolt, otherwise this system is an exact copy of the above.

A temperature recorder is fitted in the return pipe from the bearings at Stands Nos. 4 and 5 in order to indicate increase in oil temperature in passing through the bearings.

In order to make sure that each bearing in the mill has its required amount of oil, it is necessary to proportion the oil flow from the main supply risers of the stands. This is accomplished by means of calibrating nozzles in the supply lines at point of entrance to the bearings. The calibrations of the 5-Stand mill at Trostre, together with details of the lubricating oil systems, are given as an example (Fig. 12).

Grease Lubricated Bearings

Although flood lubricated bearings have been considered in some detail, they are not the only type in use in modern mills. At Ebbw Vale, for instance, roller bearings are used for both work roll and back up roll bearings at the hot and cold lines with satisfactory results.

Bearing Life

It has been mentioned earlier that the average life of the bearings in the old type tinplate works was in the region of 400/600 tons. Because of the protection afforded by the lubricant, figures obtained in the modern mill are very high. For example, the back-up roller bearings at Ebbw Vale hot line have an average life of well over a million tons of metal rolled. One bearing was recently removed after a useful life of 3,235,000 tons. In terms of the old works' output, it means that this particular bearing would have lasted about 117 years. It is the practice at Ebbw Vale to use all back-up bearings first at the cold mill and then, after a working life of 300,000 to 500,000 tons they are removed for use at the hot line where their life is at least another million tons.

The average life of work roll bearings on the hot line is 300,000 tons, but new types of bearings and techniques are being developed to improve this figure. No figures are to hand of the life of flood lubricated bearings at Trostre so far, but in the U.S.A. similar bearings have an expected life of 1½ million tons. The quantity of grease used for back-up roll bearing lubrication is very small, even when the grease is used liberally to prevent ingress of water.

White metal bearings used at the hot roughing stands give a life of approximately 100,000 tons. The maximum allowable wear is 1/16″, as it has been found to be good practice to remove them at this stage for re-metalling.

WORK ROLL BEARINGS

The present very high rolling speeds have presented the lubricant supplier with serious problems as far as work roll bearings are concerned, but these have all been successfully met. Roller bearings are universally used for work roll bearings. Generally they are lubricated from a mechanical contralised grease system as in the illustration (Fig. 13).

It is remarkable on how little grease these bearings will operate, but the grease has to be of an extremely high quality, generally of the leaded type. In a temper mill in a tinplate works, for instance, no external cooling of the bearings is possible, and as the output speed is 4,500 f.p.m. the rate of internal shear in the bearings is high. In addition, the grease must be capable of withstanding and protecting the moving parts from the terrific inertia forces due to acceleration and deceleration.

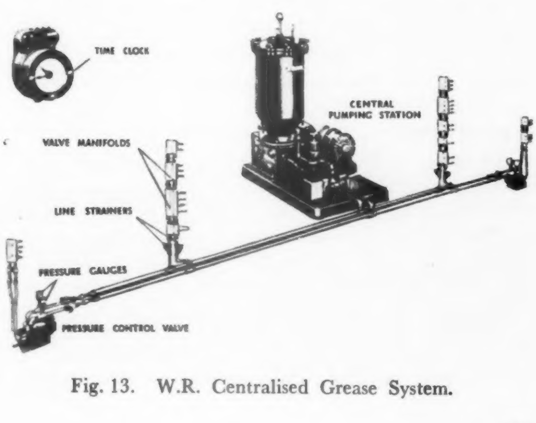


Fig. 13. W.R. Centralised Grease System.

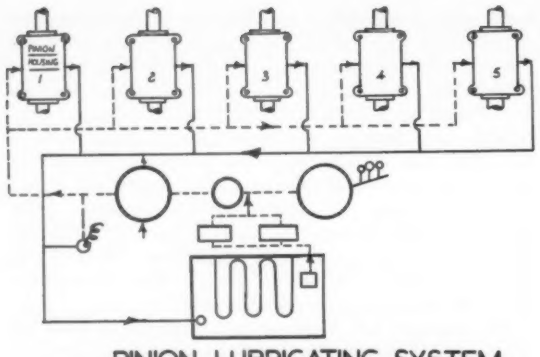


Fig. 14

It is the practice to over-lubricate the bearings in all but temper mills. This ensures that an internal pressure is built up thus preventing the ingress of scale and water.

At Trostre, the work roll bearings have very little grease fed to them during the time they are in operation. Grease is fed at the rate of .2 ozs. every 15 minutes by means of a mechanical grease system. The bearings depend chiefly for their lubrication on the prepacking which is carried out at the roll shop on assembly.

GEAR AND SCREWDOWN SYSTEMS

It is outside the scope of this paper to go fully into the subject of gear lubrication, but a few notes may be of advantage. The diagram (Fig. 14) is of a type of installation similar to that found at several big mills, and generally the circulation systems are very similar to the systems used for bearing oil, therefore, they need not be discussed in detail.

The main factors affecting lubrication are :—

(1) Type of gear.
(2) Pinion speed.
(3) Reduction ratio.
(4) Operating temperature.
(5) Input horse power.
(6) Nature of load.
(7) Type of drive.
(8) Method of oil application.
(9) Water contamination.

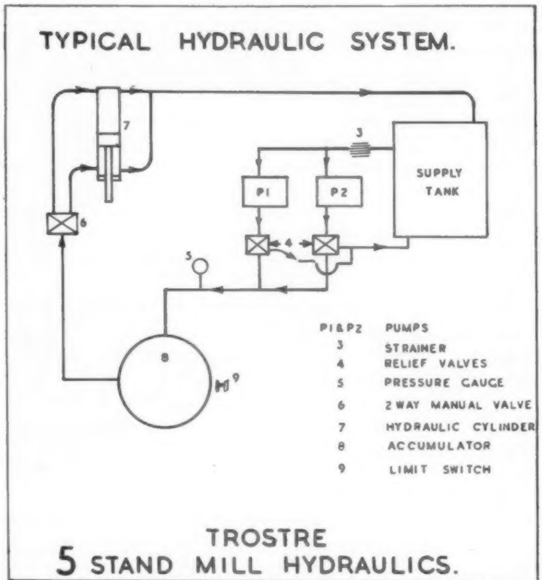
Type of Gear

On spur, helical, herringbone, bevel and spiral bevel gear teeth, the line of contact between engaging teeth sweeps swiftly without side slide over the entire working surface of each tooth, hence contact at any specific point endures for only an instant. There is little time to squeeze out the film of lubricating oil if the proper viscosity is used. Too light an oil would be squeezed from between the gear teeth and metal-to-metal contact would occur. Too heavy an oil would result in drag and increase in temperature, with the added danger that the oil, when cold, would not flow into the tooth cavity.

In a worm gear, contact on the teeth of the large gear takes place from the tops of the teeth to the root. The direction of sweep tends to form an effective oil wedge, but as speed is relatively slow, oil wedge formation is more difficult. The worm revolves at a much greater speed and has a high sidewise velocity at the line of contact. This condition would tend to form an effective oil wedge, but for the fact that the direction of slide nearly coincides with the line of contact. It is, therefore, necessary to use a heavy-bodied oil for the maintenance of the correct oil film. This is the condition obtaining at the screwdown worm drive.

Pinion Speed

The higher the speed of meshing gears, the higher will be the sliding and rolling speeds of the teeth. This speed assists in the formation of a wedge and at high speed, more oil is drawn into the pressure area. Also, there is less time for oil to be squeezed from between the meshing teeth. Comparatively light-bodied oils may be used, but at low speeds more time is available for oil to be squeezed out and less oil is drawn into the pressure area, therefore, heavier-bodied oil should be used.



SYSTEM	PRESSURE p.s.i.	TANK SIZE GLNS.	PUMP CAPACITY G.P.M.	VISCOSITY S.S.U AT 100°F.
ROLL BALANCE	1600	200	30	150/200
SPINDLE BALANCE	250	400	4	150/200
REEL STRIPPER	750	1700	36·5	150/200
UNCOILER	750	550	36·5	150/200

Fig. 15

Reduction Ratio

In a multiple reduction gear set, the oil has to cater for the slowest pinion. Whilst it is true that using a heavier viscosity oil for the pinion may cause a slightly higher operating temperature at the high speed gears, the slow speed pinion has to be safeguarded. In most gear sets, the ratio of 10 to 1 is usually catered for by a single reduction gear set, and in this instance there is no complication regarding viscosity of the oil. In worm and hypoid gears, the type of sliding between the teeth is the controlling factor in the formation of an effective oil wedge and not the reduction.

Operating Temperature

The temperature at which gears operate needs careful consideration. The heat generated by friction and by churning of the oil will increase the temperature of the oil in the base of the gear set. In a fully loaded spur, helical, herringbone, bevel, or spiral bevel gear set, the temperature rise will be approximately 50°F., this, of course, being affected by the power input. A general rule is that the temperature of gear sets should not exceed 150°F.

On the other hand, hypoid and worm gears normally operate at higher temperatures. A temperature rise of 90°F. is usual in worm gears. Air cooling is resorted to in very big sets for worm and spur gears which are heavily loaded.

Where gear sets are located in hot places or subjected to heat from outside sources, it is necessary to use a heavier viscosity oil in order to compensate for the increased temperature.

Where gear sets are located in cold places, oil with a good pour point is required and also of not too heavy a body, otherwise if the set is splash lubricated the gears will channel a groove through it, with the result that no oil will be carried to the point of mesh. In circulation oiled sets the oil might not flow to the pump suction and, therefore, would not be circulated to the point of mesh.

Input Power

In selecting the viscosity to use, apart from temperature, the tooth pressure is an important factor. The greater the pressure the more viscous the oil must be, in order to resist the squeezing action. If tooth pressures are light, a lighter-bodied oil will provide an adequate oil film with a minimum of fluid friction. With the correct oil in use, the oil wedge which is formed spreads the load over an increased area thus reducing the unit pressure on the teeth. This aids in preventing metal-to-metal contact.

Gears of low horse-power ratings are usually constructed with narrow face, small diameter and small tooth size. Those of higher horse-power ratings are of wider face, large diameter and larger tooth size. The teeth of the larger diameter gears can carry greater pressures per inch of tooth width than can be carried by the teeth of smaller gears, because the tooth profiles of the larger gears are formed by longer radii

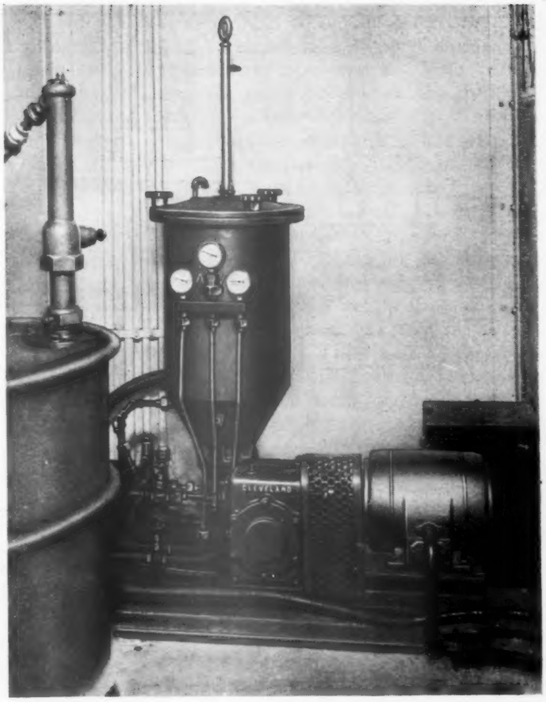


Fig. 16. Heavy duty centralised grease pumping unit.

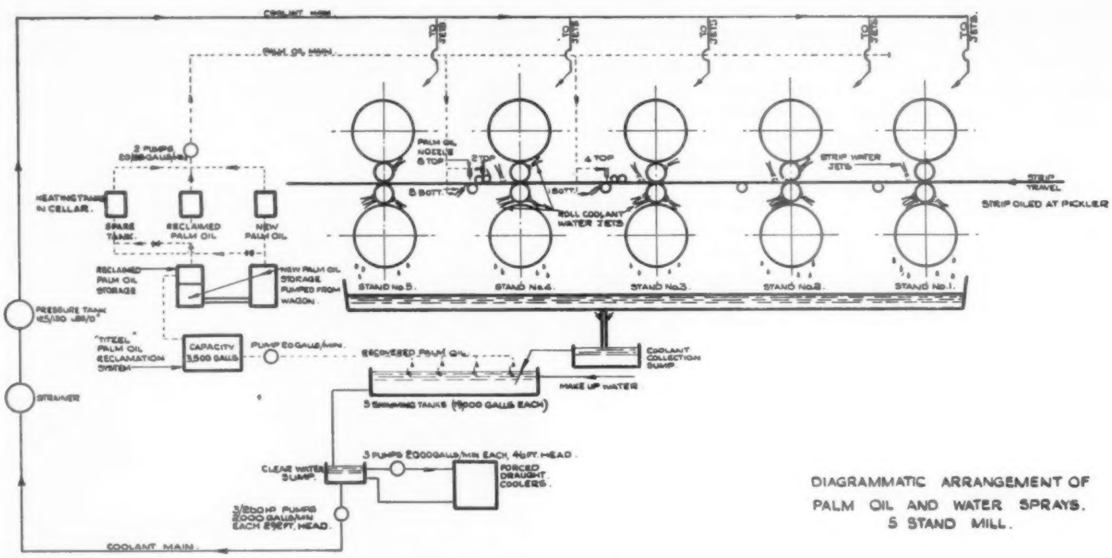
which results in wider bands of contact for similar pressures per inch of tooth width.

Input power affects the lubrication due to the heat which is generated between the gear teeth. It can usually be stated that the greater the horse-power the greater will be the operating temperature, that is unless the sets are equipped with oil coolers. This has to be borne in mind when selecting lubricants.

Nature of Load

If the load is uniform, formation of a suitable oil film is comparatively easy. Excessive tooth pressures due to shock loads, tend to rupture lubricating films that otherwise would separate the gear teeth if the load were more uniform. For shock loads it is necessary to use a heavier-bodied oil to prevent this film rupture.

In mill stands, where the gears are started under heavy loads, at times it is almost impossible to maintain an effective oil wedge. At such times boundary lubrication exists. Consequently the oil is required to have a very high film strength. Some gears are loaded so heavily that it is very difficult to maintain an effective lubricating film between loaded surfaces. This is usual in hypoid gears used in the automotive field. Metal-to-metal contact is so severe that wear cannot be avoided, but it can be controlled by using extreme pressure lubricants. These minimise, by chemical means, the welding or fusing that takes place between the high spots on the gears.



N.B. MAINS ARE SHOWN SINGLE FOR CLARITY

Fig. 17. Roll Oil Application.

Type of Drive

Electric motors provide a smooth steady drive which imposes no additional load on the transmission gears. The same applies to steam turbines, hydraulic turbines, etc., but in reciprocating engines the variable torque imposes a corresponding variation in tooth loading, so that heavier-bodied oils may be required in order to ensure an effective oil wedge at all times. As a general rule, light oils are adequate for turbine gear sets.

Method of Application

Splash lubrication is generally less effective than when the oil is circulated and sprayed directly on to the meshing surfaces. This is particularly true in the case of low speed units. Heavier-bodied oil is needed to offset this condition in order to provide sufficient oil to cling to the teeth. In a pressure circulation system there is usually better heat dissipation than with a splash lubricated system, because the oil is thrown against the inside of the gear case, thus coming in contact with a large cooling surface. Splash lubricated systems as a rule run hotter and require a heavier-bodied oil. Oils in gear sets are subjected to very heavy punishment because of atomisation and increased temperature, which tend to cause sludge.

Selection of lubricant is exceedingly important. If the oil thickens due to chemical instability, deposits will be formed and these may collect in idle spaces on the sides or in the bottom of the gear case.

Water Contamination

Water sometimes finds its way into the oiling systems of enclosed gears. It may result from condensation of moisture in the atmosphere. In such a case, it is often an indication of inadequate ventilation of the gear case and oil reservoirs. It happens more frequently on gear sets which are operated intermittently, because of alternating between warm and cold. When moisture is present it is necessary to use an oil of high demulsibility, i.e. an oil that separates quickly and completely from water.

Every effort should be made to exclude water from gear cases. If it is allowed to remain in a gear case, rusting may occur, with consequent damage to gear tooth surfaces, and in addition deterioration of the oil will be hastened. Dirty or oxidised oil usually forms a permanent emulsion, which may cause excess wear of gears and bearings by preventing the formation of an effective oil film, or by restricting the amount of flow through pipes and oilways to the gears and bearings. An oil of high stability is essential.

Regardless of the care which has been taken in the selection of the correct lubricant and its maintenance in a good condition, in practice it is found that gear teeth fail. The following is a brief outline of the most common troubles experienced with gear teeth.

Gear Tooth Failures

There are many types of gear failure, and the most common experienced is pitting. The teeth of new gears may have variations in surface smoothness. These may be too small to break through the oil films, yet they may be large enough to affect gear operation. In addition, there may be variation in the surface hardness of the metal. When smoothness or hardness is not uniform, the distribution of load across the entire tooth surface is not uniform. Thus, as the teeth pass through mesh, the load is concentrated on

local high spots or hard spots. This produces heavy localised stresses which are repeated at each turn of the gear, until eventually sub-surface fatigue of the metal causes minute particles to break away, leaving small pits where high spots or hard spots have been. This action always takes place at or slightly below the pitch line. Investigation has shown that when these pit holes have occurred, the holes have become filled with lubricant, and hydraulic pressure is developed. This tends to extend the cracks and eventually to lift out the small particles of metal. Continuation of this may lead to destructive pitting.

It is interesting to note that pitting occurs when there is a low ratio of slide to roll. With worm and most hypoid gears, excessive side slide tends to wear away high spots before true pitting occurs. With spur and bevel gears, as each tooth passes through the centre of mesh the entire load is momentarily concentrated on the pitch line. If the area along the pitch line has pitted, this concentration of load on the roughened surface can increase the pitting until the tooth surfaces are destroyed. On the other hand, with helical, herringbone and spiral bevel gears, there is less likelihood of destructive pitting. This is because each tooth, during mesh, makes contact along a slanted line which extends from root to tip. This line cuts across the pitch line, and though pitting may have roughened the area along the pitch line, the line of contact always extends beyond this roughened surface, and thus the load is carried on undamaged root and tip areas. Pitting may, therefore, cease as soon as the few high spots along the pitch line have been removed. On new gears pitting often takes place until the gears have been run in. Also, pitting is more likely on wide gears because of the difficulty of obtaining absolutely true alignment. Whatever lubricant is used pitting can take place, but with the use of the correct lubricant it can be minimised and usually stopped if the gears have been run in.

Abrasion

In dusty surroundings the circulating oil, although totally enclosed, can become contaminated with grit. This grit is carried to the mesh and will cause wear. If the teeth are fairly soft, wear can take place very rapidly. If the abrasive is of a fine nature, the tooth surfaces may show a high polish, although excessive wear occurs. This abrasion cannot be prevented by oil, but it can be stopped by filtering the foreign material out of the oil.

Scoring

When sharp projections on the surface of gear teeth penetrate the oil film, they can score the surface of the mating teeth. Rough finish, pitted surface, or misalignments may be the cause.

Spalling

Spalling is due to misalignment, overload, or, in fact, any condition that stresses the metal beyond its fatigue limit. This over-stressing causes the sub-surface of the metal to fail, with the result that large

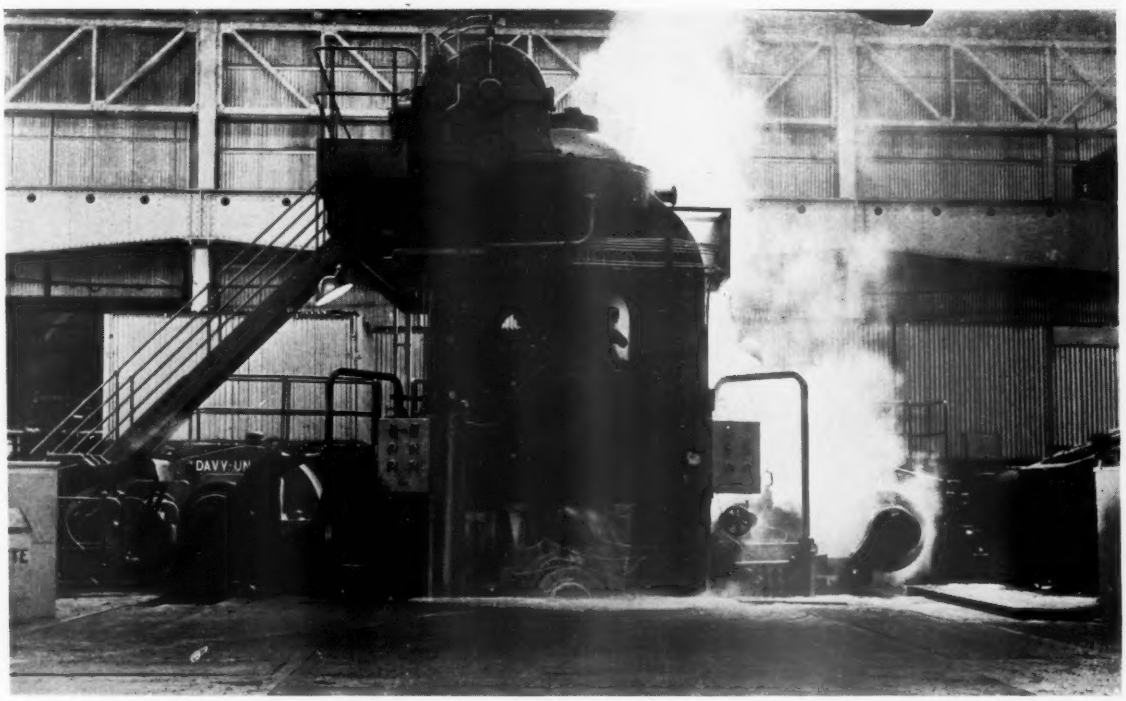


Fig. 18(a). Lysaght Reversing Mill.

flakes of metal are rolled or sheared from the rubbing surface of the teeth. With hard metals, pieces break away, leaving fairly large pits and holes. With softer metals, a peening action may occur, which rolls thin flakes of metal from the working surface, but leaves the teeth surface in fairly smooth condition. Most of these troubles are due to mechanical conditions.

Galling

Galling is due to failure of the oil film to carry the load, either because the operating conditions were abnormally severe, or because the oil was incorrectly selected. In either event, the thick wedge-type film has given way to the microscopically thin, boundary-type film which, in turn, lacks sufficient film strength to protect the gear teeth from excessive friction and plastic flow of the skin surface of the metal.

It will be seen that when a full-fluid film fails, the first signs of wear occur at or near the pitch lines of the teeth. The teeth then usually show evidence of a yielding and sliding of the surface and sub-surface metal. This yielding then progresses towards the tips of the driving teeth and towards the roots of the driven teeth. The whole surface of the teeth can become affected. Failure of the lubricating film may cause pressure welding or seizure between the engaged surfaces. In such an event, welding occurs, chips and scales of metal tear from the teeth, and the working surfaces become roughened. Excessive wear will probably follow.

HYDRAULIC SYSTEMS

Hydraulic power is used to actuate most of the works handling mechanisms in a modern mill. In the old days, it was customary to manhandle the products, but this is no longer possible or desirable. All roll adjustment, coil handling, roll balancing, coil tensioning, and many other operations use this valuable type of power. Mechanical handling has been brought to a fine point of perfection.

Most hydraulic machines work to very close tolerances. The slightest inefficiency in the operation of the hydraulic system may mean erratic handling, with consequent fall-off in the quality of the product. Failures can often be traced to the fluid medium employed, or to the manner in which the fluid medium is handled. Gummy deposits are generally attributed to the oil, but this need not necessarily be so.

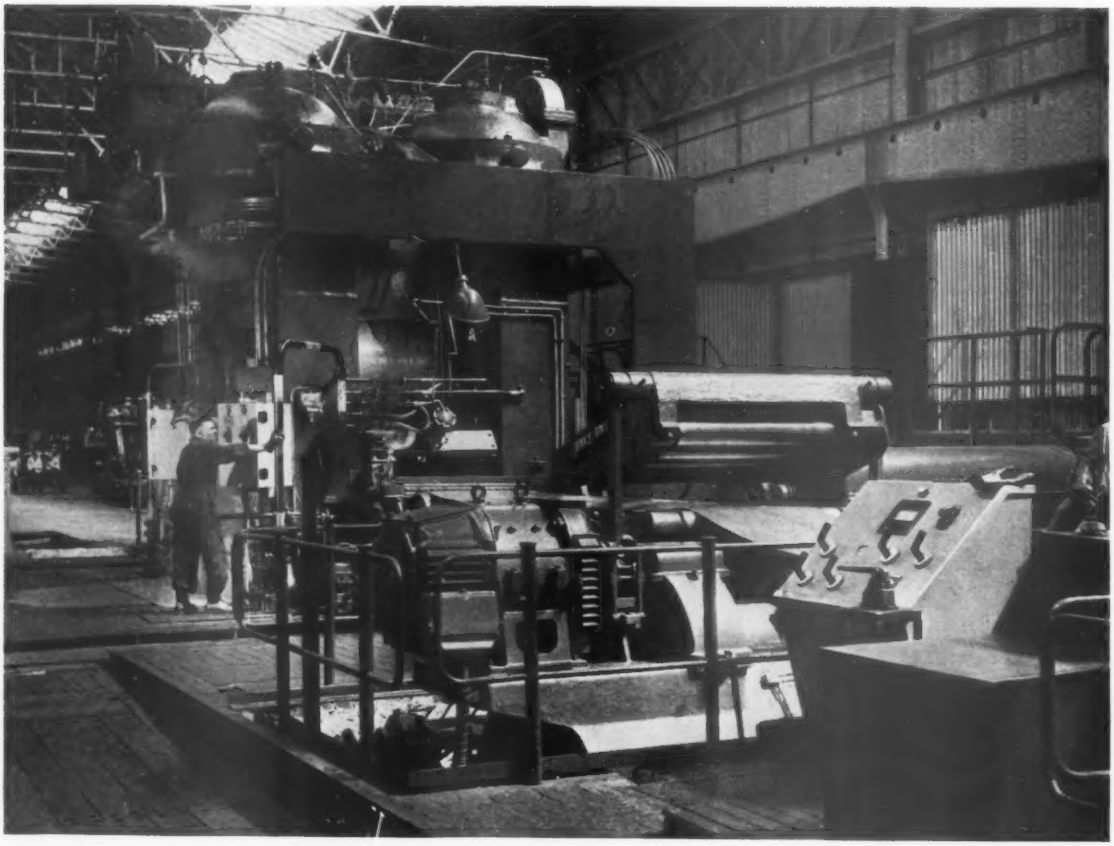


Fig. 18(b). Lysaght Reversing Mill.

The gradual decomposition of flexible rubber hose under the action of the warm oil may produce deposits that clog the system and prevent its proper functioning. Care should be exercised in the selection of the rubber hose which is exposed to warm oil in this fashion. Gummy deposits can also result from the use of an unsuitable paint on the inside walls of the oil tanks. Such a paint would soften and flake under the action of the warm oil.

Excessive Leakage

This is one of the most serious problems experienced with hydraulic systems in mills. In some systems, regardless of the care with which they are maintained, it is impossible to keep them oil-tight. As this entails heavy make-up, the oil does not remain in the system for a long time, therefore, the full qualities of a top-grade oil cannot be utilised. In such cases the use of a less costly oil is justified. On the other hand, if the systems are oil-tight, the better the quality of the oil, the greater will be the ultimate saving.

Great care should be taken to exclude dirt, as grit or abrasive material in a hydraulic system not only impairs the smooth action of the pumps, valves and cylinders, but may also score the rubbing surfaces. This scoring will cause internal and external oil leakage and increased power consumption. Many manufacturers incorporate filters in their systems.

Excessive Heating

When a pump discharges oil at a higher pressure than is necessary for efficient operation, the excess pressure is dissipated either through a relief valve, or by increased slippage through clearance in various parts of the machine. This dissipation of pressure, without doing any productive work, results in an increase in oil temperature. Therefore, adjustment to the correct operating pressure is important to keep the operating temperatures normal. Internal oil leakage resulting from excessive clearance due to wear will also cause an increased oil temperature, although the pressures may be correctly regulated. This can only be overcome by the correction of the mechanical causes.

Air in the System

To ensure smooth action of valves and operating cylinders, it is essential that an undiminished oil pressure is supplied to all parts. Undiminished pressure is possible because of the fact that oil is practically incompressible. This is true only as long as the system contains no free air. Erratic action of valves and systems occurs when air is present. In addition, the presence of air may cause foaming. This is due to the fact that air is soluble in oil, and the higher the oil pressure, the more air can be held in solution. For example, at 77°F. and at atmospheric pressure, 27.5 cubic inches of air can be dissolved in a gallon of oil. At 200 p.s.i. and at the same temperature, approximately 386 cubic inches—that is, 14 times as much of atmospheric air—can be dissolved in the same gallon of oil. Air in solution does not impair the incompressibility of the oil. As long as the oil is under pressure the air remains in solution, but when the pressure is relieved, the air is released as fine bubbles, which may cause foaming in cylinders, return line, and reservoirs.

Oil containing foam is no longer incompressible, and is most undesirable in any hydraulic system. The removal of free air by venting may temporarily remedy the foaming, but the permanent remedy is to locate and seal the places where the air enters the system. Air in an hydraulic system may seriously affect the performance and durability of the oil, because of the local overheating which may take place when the air bubbles present are compressed. Air usually enters the system through small openings in the suction lines, or *via* the packing glands; also, too low a level in the tank would permit free air to be drawn in by the pump suction. Return oil pipes should be submerged so as to prevent cascading and the trapping of air.

Selection of Oil

Oils for hydraulic systems must have exceptional chemical stability. Oils differ in chemical composition and, therefore, in stability. In the hydraulic system, constant circulation and churning in the presence of oxygen tend to change the oil chemically. Oils that cannot resist this tendency thicken and become sluggish in service. This retards the operating cycle and slows down production. The machine eventually becomes less reliable in its action, because of the gummy deposits. It is, therefore, essential that the oil resists this chemical change for as long as possible. As oxidation is accelerated by heat, operating temperatures should be kept as low as possible, in any case not above 130°F.

Water must be kept out of the systems. If contamination occurs, steps should be taken to remove the water as soon as possible. The oil must be capable of separating readily from water, hence it must be of good demulsibility.

Film strength is important, because not only do hydraulic oils serve as fluid media for transmitting pressure, but they act also as lubricants for pumps, cylinders, valves, etc. Pressure between some of these moving parts may be extremely high. In order to prevent excessive wear, hydraulic oils must provide strong lubricating films between the moving parts at all operating temperatures. Since an oil film under these conditions is of microscopic thickness, it must possess extremely high film strength.

An important factor in respect of internal leakage, or what is called slippage, is viscosity. Although this leakage does not involve actual loss of oil from the system, it does lower the capacity of the pump and it also increases the oil temperature. In variable stroke piston pumps, moderate slippage can be compensated for by lengthening the stroke of the pumps. In a gear or vane pump, where a by-pass relief valve controls the discharge of pressure, the volume of oil discharged is always greater than the demands of the working cylinders and the excess oil flows through the relief valve back to the tank. Moderate slippage of the pump, therefore, merely reduces the flow of oil lost through the relief valve.

In order to minimise slippage and maintain maxi-

STATION —

PLANT: 5 STAND MILL (STANDS 1 & 2) MORGOILS

TANK A.2. CAPACITY 3500 GLNS.

GRADE

F 3274

SAMPLE	1	2								
DATE	22/4/52	26/8/52								
SOURCE										
S.G.	·899	·900								
POUR										
FLASH (o)	490	485								
FLASH (c)										
RED 70										
100	1220	1493								
140										
200										
SAY 100	1391	1702								
APPEARANCE	CLEAR	DARK								
COLOUR										
COMP.	—	—								
N.V.	0·11	0·14								
R.E.										
FUEL										
CARBON										
OIL										
WATER IN OIL	NIL	TRACE								
" ~~SLUDGE~~ FREE	NIL	NIL								
SILICA										
IRON OXIDE										
COPPER OXIDE										
CALCIUM OXIDE										
SULPHUR										
CHLORIDE										
FREE METAL										
IMPURITIES	NIL	TRACE								

Fig. 19. Record Card.

mum pump capacity with minimum power consumption and low oil temperature, it is most important to use an oil having a viscosity which is most suitable to the particular design of pump. Since the choice of viscosity is influenced principally by the design of the pump and, to some extent, by the nature of the system, it is always wise to co-operate closely with the various manufacturers.

It is important to employ an oil which has a high viscosity index, that is, an oil which changes its viscosity as little as possible with an increasing temperature. Fig. 15 shows a typical hydraulic system at Trostre, and details of the hydraulic systems at the 5-Stand mill.

The roll balance system has an accumulator to keep the pressure constant. There is little or no fluctuation, as the load is always being applied. Two pumps supply the system.

The spindle balance is also a constant pressure system, but the system is so small that an accumulator is not needed, a pressure vessel being used instead One pump only is needed, as the quantity is only 4 g.p.m.

The reel stripper system is a fluctuating load and has several operations to perform, such as stripping the reel and lifting the coil. It also operates the outboard bearing on the coiling reel. There are three pumps in this system which can cut in when the load makes it necessary. No pressure vessel is fitted; the pressure and relief valves take care of any excess pressure.

As this is a fluctuating load, the pumps supply directly into the line. The two pumps are regulated by automatic unloading valves.

CENTRALISED GREASING SYSTEMS

In a modern mill, it is usual for as much as possible of the lubrication to be made automatic. Oil circulation systems have been dealt with at some length, but it is true to say that a very high percentage of lubrication is carried out by means of centralised greasing systems (Fig. 16). Several systems are available, and they are all highly efficient. They are all designed to supply a measured quantity of grease to a bearing from a central grease container at set

intervals. One system may take care of several hundred bearings.

All greases applied by means of mechanical equipment must of necessity be soft. The grease lubricator determines the consistency of the grease which can be used. Even so, greases are produced which, whilst still very soft, possess very high load-carrying properties. The best type for general mill applications are the lead-lime type, in which high viscosity oils are used. One essential property of the greases which is to be used in mechanical systems is that it will not separate out to its constituents when under pressure.

ROLLING OILS

Time or space will not permit of a full discussion on rolling oils, but owing to its importance from the production standpoint, it is desirable to mention one or two facts in passing. As already mentioned, in the old days no lubricant was required, because of the low speeds. In a cold reduction mill, rolling as it does more than a ton a minute, heat generated is very high and wear and tear on the work rolls would be excessive if no lubricant were used. In fact, rolling with heavy reductions would be impossible. In addition, rolling metal dry puts an increased load on the power supply. Therefore, it is universal practice in cold rolling to use a lubricant of some form or other. This holds good for all rolling except temper rolling, which is carried out dry.

In the rolling of steel sheets down to approximately 0.010″ gauge, soluble oils have proved themselves to be quite adequate. Soluble oil emulsions are suitable even for the rolling of Stalloy. It is only when the speed increases to 3,000 f.p.m. and the gauge is below 0.010″, that resort has to be made to other than soluble oil emulsions for the rolling of steel. Several mills operate successfully on aqueous emulsions, but it is true to say that those which approach the 3,000 f.p.m. on a 4-Stand type of mill need an additional application of a soluble oil to the nip of the rolls. When speeds are higher than 3,000 f.p.m. and when gauge is down to .0085″, it is usual to use palm oil. The methods of applying this are very numerous, and on examining 12 strip mills in the U.S.A., the Writer found that the number of ways of application was greater than the number of works visited, because within the same works where more than one set of 5-Stand mills or 4-Stand mills were running, different methods of application were used. The method of application and palm oil circulation system at Trostre are shown in Fig. 17.

At Lysaghts, where silicon steel is cold reduced from .08 to .013, a soluble oil emulsion of 5% is used (Figs. 18(a) and 18(b)). Pump capacity is 900 g.p.m. Two tanks of 6,000 gallons capacity are used, so that one can settle and the scum be skimmed off whilst the other one is in use.

Many experiments have been carried out by the leading oil companies, both in this country and in the U.S.A., to find a satisfactory substitute for palm oil, because it has many disadvantages. For example, it quickly freezes at normal temperatures and, therefore, all palm oil pipes have to be steam-traced. It does not readily form an emulsion and it cannot easily be reclaimed. It is a problem which the leading petroleum companies' technologists have very much in mind at present.

MAINTENANCE OF CIRCULATORY SYSTEMS

In all the big systems lubricants worth many hundreds of pounds are in circulation, but more important is the very high value of the machinery which this oil lubricates. Therefore, it is most important that the oil be kept in the best possible condition. Samples should be taken periodically for examination, in order to ascertain the exact condition of the oil. This is a service which the leading oil companies carry out for their customers. Record cards (Fig. 19), which carry the full history of the charge in circulation, are kept, therefore a close control of the oil condition can be maintained. Any contaminants must be removed as quickly as possible, to avoid the formation of permanent emulsions. The longer any water remains in the oil in the presence of other contaminants, the more difficult it will be to remove, as it becomes intimately dispersed within the oil.

The use of centrifuge for clarifying the oil is of advantage. The centrifuge can also be utilised to separate small quantities of water out of the oil.

Splitting of Emulsions

However tight bearing seals may be, a broken pipe or damaged seal can allow ingress of rolling medium, which is probably an emulsion of water and oil, into the circulating oil system.

It has been found in practice that emulsions are frequently formed. Generally these emulsions can be easily broken if steps are taken without any undue delay to split off the water. It is here that the merit of a second tank becomes apparent. For ordinary emulsions, resting the oil, raising its temperature to approximately 180°F., and holding it there for about 12 hours, then allowing it to cool, is all that is necessary to bring the oil back into working condition. Any traces of water still remaining in the oil can be removed by the use of a centrifuge. Splitting emulsions in this fashion is important because, although the emulsion itself might still be a good lubricant, there is the danger that it will rapidly thicken and choke the pipes leading to the mill and, in addition, it is possible that the cavities in the bearing will become choked. If a more permanent emulsion is formed, as can conceivably happen if the circulating oil is badly contaminated, particularly with mill scale, etc., it may be necessary to resort to the use of a newly-developed chemical emulsion breaker in order to bring about the desired effect. Until recently a stubbornly emulsified oil, as described, had to be rejected, the system cleaned out, and a new charge of oil introduced.

Research by the oil technologists has resulted in the formulation of emulsion splitters, which are capable of separating stubborn emulsions formed in rolling mill systems which could not be dealt with by previously-known methods. The oil in the tank is put out of service and heated to a temperature of 190°F., circu-

lating the oil within the tank and adding the recommended quantity of chemical emulsion splitter. Such a small quantity of splitter is used that it is necessary to circulate the oil and the emulsion splitter for from 30 to 60 minutes, in order to obtain the correct dispersal.

After thus mixing, the oil should be allowed to settle for a period of up to 24 hours, when complete separation of the emulsion will take place and the water can then be run off. This shows a very great saving, because in modern systems the oil in circulation may cost anything up to £2,000. The cost of the emulsion splitter would be less than £10. This chemical emulsion breaker has been successfully used where the emulsion has resisted splitting by any other means.

STANDARDISATION OF GRADES

From the production standpoint, lubrication is an essential requirement and it is in the interest of everyone concerned to reduce lubrication to a point where it causes as little trouble as possible, whilst at the same time enabling efficient production to take place. To this end, standardisation of grades is successfully resorted to in many works. By careful consideration of the separate units and consultation with the specialist engineers of the oil companies, the number of grades can be greatly reduced. For a normal works, excluding transport, the number of grades should not exceed 20, including greases. By standardising in this way, the quantity of stock carried can be less, stores handling can be easier, and operators will be less confused. Moreover, an all-round monetary saving can be shown.

It might be argued that in standardising, grades of lubricants are sometimes used which are better than need be and, therefore, are more expensive. A breakdown of, say, a hot line for eight hours will cost more than the cost of all the lubricants used in the works in a year.

OIL DISTRIBUTION

Far more thought is being paid to this today than in the past. Quantities of lubricants used have increased to such an extent that handling of barrels, for instance, has become a major problem. In order to cut out barrel handling on the mill floors, it was decided at Trostre to install bulk storage tanks in the cellars. These could be filled directly from road tank wagons and the oil from this point was piped to the points of heaviest consumption. By doing this, the cost of handling has been very greatly reduced, as also has the initial cost of the lubricants, as bulk deliveries can show a considerable saving per gallon. Where it is impossible to follow such an ambitious programme, much can be done in distributing the lubricants to ensure clean handling and a clean works.

The ease with which the distribution of lubricants can be carried out is closely allied to the number of grades in use. Therefore, close co-operation between lubricant supplied and works personnel is essential.

QUALITY OF LUBRICANTS

This question is very important. Where the first consideration is quality and quantity of production, the lubricant must be capable of withstanding continual use under very arduous conditions for a lengthy period. One main requirement is that the oil is of a very high chemical stability. This will prevent the formation of sludge, with possible dangers of mechanical breakdown. The viscosity is important, particularly in such applications as film-lubricated bearings, where it is necessary to keep the fluid friction under close control. The oil must separate readily from water, hence it must have a good demulsibility. Film strength, too, is very important, particularly in gear lubrication.

Conclusion

Continuous production from any mill depends to a large extent on the efficiency of the lubrication of the plant, but this applies even more so to the modern type of mill. It is essential to have a very close co-operation existing amongst the maintenance personnel, the production staff and the lubrication specialists. The training of works personnel in order to make them lubrication-conscious will pay handsome dividends. Great saving can be effected by efficient lubrication and the correct servicing of the circulation systems. As the production man is very concerned with the costs, this will appeal to him. Apart from the actual savings brought about by using the correct products, an inestimable saving is effected by making it possible to have continuous production. The overall cost of lubricants in the plant when reckoned in terms of production is very, very small, but the effect is probably greater than that resulting from any other single factor.

So, in conclusion, it can be said that an efficiently lubricated plant reduces maintenance and lubrication costs, improves the product, reduces power consumption, and makes possible more continuous production, thus showing considerable economies all round.

Acknowledgments

The Writer wishes to express his gratitude to all those who have contributed in making this Paper possible, in particular, to the Steel Company of Wales, Ltd., and Richard Thomas and Baldwins, Ltd., for granting permission to publish the photographs and details of their plants mentioned; to the Eaglebush Tinplate Company and staff for certain sketches; to the Vacuum Oil Co. Ltd., for permission to use relevant information; to the manufacturers who have allowed details of their equipment to be included; to his colleagues for their unstinted help; and, finally, to Mr. H. P. Sanderson, Hon. Secretary of the West Wales Section, for the assistance and encouragement he has given so freely during the preparation of this Paper.

COMMUNICATIONS

The following comments on Mr. Williams' Paper have been received :

From: **Mr. G. D. Jordan,** M.Eng., A.F.Inst.Pet., A.M.I.Plant.E., Lubrication Engineer, S. Fox & Co. Ltd., Stocksbridge Works, nr. Sheffield.

Mr. Williams' Paper is a further contribution to the dissemination of knowledge about a subject of constantly increasing portent. The progress of lubrication techniques in the steel and tinplate industries is unfortunately only of relatively recent origin and has been caused, to a large extent, by the vast post-war development schemes in those industries. Modern plant demands up-to-date lubrication. High operating speeds, critical loads, and a desire for "non-stop" outputs are all exacting conditions which require insurance against mechanical faults and production stoppages. This depends for its success on foolproof methods of lubrication, and the use of correct lubricants which can function to optimum effect under the operating conditions demanded of them. Never before has lubrication assumed such importance or received such attention, attention practised not only during the design stages of plant development, but also subsequently during its working life.

Mr. Williams has covered a very wide field in a most able manner. If any criticism can be directed at his Paper, it is only for the very reason that such a wide field has been covered, as a result of which it has been necessary to refer to certain matters rather briefly. This is not the author's fault, any restrictions having resulted, presumably, from an urge to cover as many points as possible in the time available.

For instance, the steel industry of this country still possesses much plant whose operational life has been extended beyond that originally contemplated, and whose output has been increased well above its designed capacity. Under such conditions, lubrication has as vital a part to play as with more modern plant. The application of modern techniques to the lubrication of old plant can, in many cases, incur far-reaching benefits. This is an aspect of lubrication whose potentialities have not perhaps yet been fully explored.

Perhaps too much emphasis has been placed on the lubrication of gears (important as this is) at the sacrifice of more information on, say, rolling oils. There appear to be many conflicting views on the use of rolling oils. So many factors are involved; product finish and shape, roll life, annealing troubles and so on. The use of soluble oil emulsions in lieu of straight oils, emulsion strengths, methods of application of the roll oil to the rolls, all appear to be matters subject to the whims of the particular mill. A constant puzzle has been the failure to find a satisfactory substitute for palm oil (though this is now claimed in the U.S.A.) which as Mr. Williams points out, has many disadvantages. It is good to hear that this is a matter of concern now occupying the mind of the petroleum technologist.

Mr. Williams will have done much by this Paper if he has contributed towards convincing production and engineering management of the need for giving serious consideration to the lubrication of plant, and if perhaps there is, in addition, a realisation that the industrial lubrication engineer has an important contribution to make towards the successful, continuous operation of plant, both old and new, then Mr. Williams will have made a worthwhile contribution. Both "production" and "maintenance" can benefit from a better understanding of modern lubrication techniques and their role in industrial efficiency.

From: **Mr. H. Peter Jost,** A.M.I.Prod.E., General Manager, Trier Bros Ltd., London.

Lubrication is an important link between power and production and is rapidly becoming a subject of great importance to production engineering. This development has been most pronounced in some heavy industries, where the specialised lubrication engineer now fulfils a function similar to that of the tool engineer, or time study engineer, in the lighter mass production engineering industries.

Hand Mills

An important problem not fully explored by Mr. Williams is that of the lubrication of the older type of hand mills. Failure to install modern lubrication systems on this type of plant is, in the Writer's opinion, due to a number of factors, the most important of which are :

Firstly, the mistaken belief by management of the operating companies that the present type of mills has served them well for a good number of years; in actual fact, however, if the matter were fully investigated, it would soon become evident that the older types of mills, with hand-applied lubrication, are a considerable brake on production, and a source of large replacement expenditure. Their conversion to automatic lubrication by means of simple mechanical lubricators—an example of which is illustrated in Fig. A—will, in most cases, be highly beneficial to production and profitable to the business.

Secondly, the fear that if the Iron and Steel Board recommendations, as to control of production, are put into effect, most of these mills might be out of work.

The third difficulty is that of adapting the lubrica-

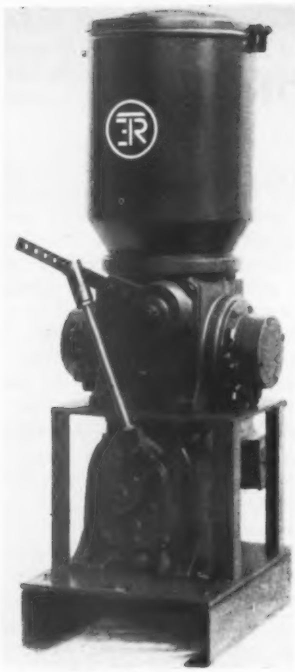


Fig. A.

tion system; this is mainly due to the compactness of the housing of the old types of machines and, in many cases, the necessity of modifying chocks and bearings.

Investigation of the problem, however, will reveal that modern lubrication systems will not only increase production, but also increase quality and reduce replacement expenditure and breakdowns.

Greases

The Writer cannot agree with the author's statement that there is an efficient grease block; at its best, grease block lubrication is an inefficient method of lubricating—this for very obvious reasons.

On the whole it would appear that lubrication by means of grease, as distinct from oil lubrication, has received insufficient treatment by the author. Grease lubrication is coming to the fore to an ever-increasing extent, not only in steel works but also in the lighter industries.

Greases are more easily handled, more resistant to high bearing pressures and more economical. They are less readily forced out of bearings, less affected by changes of temperature, and less dirty in use. They form a better seal against the entry of grit and dirt which is of particular importance in iron, steel and cement works. In fact it has been found a good practice to over-feed bearings slightly, so as to "wash out" any dirt which may have collected at the end of the bearing.

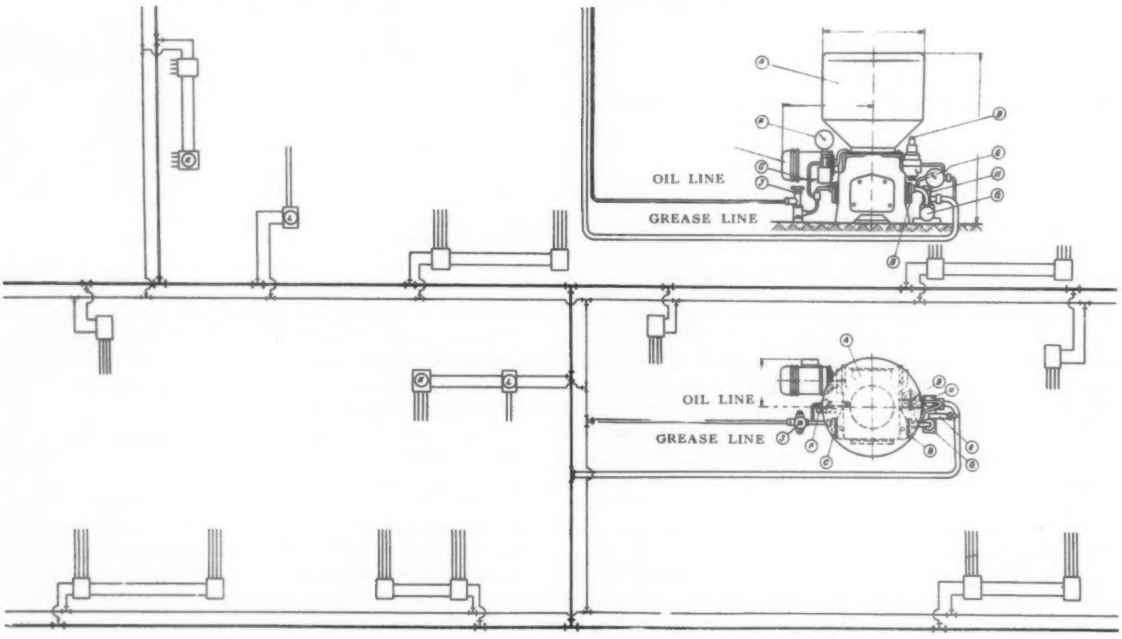


Fig. B. Oil actuated multi-point grease lubrication system for large installations.

(a) Staufferlube Multigreasors.
(b) Grease Pump Element.
(c) Oil Pump Element.
(d) Regulating Valve.
(e) Grease Pressure Gauge.
(f) Oil Pressure Gauge.
(g) Grease Strainer.
(h) High Pressure Valve for Grease Line.
(j) High Pressure Valve for Oil Line.
(k) Four-way Distribution Element.
(l) Two-way Distribution Element.

The unit is driven by a 1 h.p. motor.
All grease lines, e.g. heavy lines, $\frac{1}{2}''$ gas.
All oil lines, $\frac{3}{8}''$ o.d.

There are now modern grease lubrication systems which permit the *positive* feeding of several hundreds of points, so that the previous difficulty of grease lubrication, viz. the difficulty to feed *positively* the required amount of grease over long distances, no longer exists.

Large Lubrication Installations

In the case of larger type lubrication installations, as described in Fig. 17, because of the fact that both lines contain grease which is used not only for feeding purposes, but also for purposes of controlling the distribution elements, difficulties are often encountered, owing to the very high control pressures required. The latest type of lubrication system, for the larger type of mills, employs oil as a controlling medium, which offers very much less resistance in pipe lines, thereby overcoming the above drawbacks. Fig. B shows a typical system of this nature.

Oil controlled grease lubrication systems have the additional advantage of facilitating the use of the controlling oil for purposes of lubrication, i.e. the same general system will lubricate grease as well as oil lubricated bearings.

Finally, the Writer wishes to agree with Mr. Williams' remarks on the quality and selection of lubricants; for maximum economy and efficiency it is important that the correct grade of lubricant is used. This is by no means an easy task, bearing in mind that even one of the smaller manufacturers of lubricating grease produces over 150 different grades. This fact points to the importance of Production Engineers acquiring more knowledge of problems of lubrication, and in the Writer's opinion Mr. Williams' paper has fulfilled a valuable service by emphasising the very close relationship that exists between lubrication and production engineering.

From: **Mr. E. V. Paterson,** Editor, "Scientific Lubrication".

Mr. Williams' paper is particularly valuable because it gives practical help to a number of people. Few members of the Institution of Production Engineers are lubrication engineers and many may well be very surprised to realise the important role this subject plays in production. This fact is emphasised in the author's remarks concerning bearing life. Before the introduction of modern methods of lubrication, and modernised plant, bearing life in old type tinplate works was 400/600 tons; today it is 300,000 to 500,000 tons. Obviously this increase is not solely due to the use of modern methods of applying the latest lubricants, but it is true to state that the modern plant would be little better than the old unless correct attention were given to lubrication. This is why the title to this Paper is a good one and means what it says; the development of steel and tinplate works is closely tied up with developments in lubricants, lubricating methods and processing oils.

The Paper is valuable to those who actually work in steel and tinplate works because many engineers are inclined to take these modern systems for granted, and in view of the assistance they receive from the oil companies, perhaps do not realise the seriousness of any error being made.

Engineers in all industries, from the fitter's mate to the chief designer of the largest liner, are realising the importance of lubrication more than they have ever done before. It has been stated by Professor Vogelpohl that from one-third to one-half of the energy produced in the world is consumed by machines when idling; this energy is consumed by frictional waste causing wear and tear. The possibilities of savings to be effected by improved lubrication abound in every industry, but perhaps it is in the rolling mills that really large savings can be quickly effected.

A book could be written on the subject that Mr. Williams has tackled, but his Paper concentrates attention upon this important subject and it should convince Production Engineers that correct lubrication is a fundamental matter which must be right before commencing to consider other methods of increasing output.

Some figures concerning some lubricating equipment at rolling mills in South Wales might be complementary to Mr. Williams' Paper. At the Margam works alone, the oil systems contain some 132,000 gallons of lubricant, and grease is fed to more than 12,000 bearings by centralised systems.

At the Abbey and Trostre Works of the Steel Company of Wales, more than £250,000 was spent on centralised lubrication systems, including all pumps, tanks, filters, etc. The Davy United cold reduction mill, a three-stand wide strip mill, can roll at 2,035 ft./min. which is the fastest for this type of mill anywhere in the world.

Finally, Mr. Williams' Paper should be read by plant and lubrication engineers, especially those engaged in other industries, for there are many matters discussed which apply to similar plant outside the rolling mills, notably the remarks concerning gear lubrication and hydraulic systems.

RESEARCH PUBLICATIONS

A number of copies of the following Research publications are still available to members, at the price stated:

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research and Development	10/6
Practical Drilling Tests	21/-

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge," Melton Mowbray, Leics.

JOURNAL BINDERS

Members are advised that binding cases for the new size Journal are now available, and may be ordered from Head Office. The cases, which are strongly made and covered in dark red leather cloth, with "The Institution of Production Engineers Journal" in gilt on the spine, will each hold 12 copies of the Journal. The price per case is 10/-, post free.

THE PRACTICAL APPROACH TO ENGINEERING FINE SURFACES

by D. B. EBSWORTH, A.M.I.Prod.E.

Presented to the Gloucester Sub-Section of the Institution, 1st October, 1953.

Mr. Ebsworth served his apprenticeship with The Bristol Aeroplane Company, (Engine Division) between 1929 and 1935, during which time, under the guidance of the Company, he received his technical education at the Merchant Venturers Technical College, Bristol. Subsequently he spent brief periods at Pobjoy Air Motors, Wolseley Aero Engine Ltd., The Alvis Motor Car Company, (Aero Engine Division) and The Austin Motor Car Aero Engine Shadow Factory, returning ultimately to The Bristol Aeroplane Company, (Engine Division) as a Quality Observer.

During the War period Mr. Ebsworth acted as General Liaison between Quality Manager and the various dispersal points on matter affecting quality, and was concerned with the investigation of service troubles.

In 1947 he undertook the duties of Chief Quality Observer and twelve months ago was appointed Technical Assistant to the Chief Inspector, Rodney Works, where the sheet metal and light section components of Bristol Engines and Engine Power Plants are manufactured, with special instructions to find and develop methods of measurement best suited to the requirements of the flexible but close toleranced components of gas turbines.

Mr. D. B. Ebsworth

THE problems facing an engineer concerned with the production of suitable surfaces on engineering components are legion in number, but may be considered to come under the six following headings:

1. To determine and produce consistently the class of surface necessary for the functioning of the components, whether they be moving or stationary.
2. To select the method of finishing which will give the necessary dimensional control.
3. To produce the required surface mechanically in such a manner that it needs the least amount of hand fitting and the shortest running-in period.
4. To develop a surface which will give maximum life with minimum wear.
5. To select classes of surfaces and methods of producing them which do not create the risk of fatigue failure or lower the physical properties of the material in highly stressed parts.
6. To select surface treatments or coatings necessary to protect the part from the effects of fretting and corrosion which may be harmful to its function and life.

With most forms of engineering these are special problems and will be dealt with as the needs of that form dictate. This Paper will deal largely with problems associated with the production of high-powered aero-engines, where cost is perhaps not so critical as in more commercial applications. Nevertheless, it has its ever present need for control and it has been found that the best surface is not directly proportional to cost.

When referring to the quality of surface finish, it will be quoted in micro-inches and will have been measured on either a Taylor Hobson "Talysurf" or an Abbott Profilometer. It is not proposed to discuss the mathematical differences between the two methods of measurement, but as a matter of interest each will be referred to by its own tally: that is, Centre Line Average Height for measurements made by the Talysurf, and Root Mean Squared by the Abbott. Both types of instrument have their particular virtues and we try to extract the best from both. Our problems are largely divided by materials and we will therefore take steel components first.

Generally, steel components are those carrying the most arduous duties in an engine and this combined with the very nature of the medium provides the majority of interest.

Steel may be milled, turned, planed, polished, ground, honed and lapped. In the study of fine

surfaces we are concerned mainly with the last three and with polishing as a medium for finishing irregular shapes.

Grinding

Grinding is the general way of finishing steel, but it requires a high degree of skill to repeat continuously a restricted grade of surface to fine dimensional tolerances and brings in its train a number of pitfalls.

In an endeavour to produce fine finishes by grinding, there is a grave danger that the surface may be burnt and grinding cracks formed. These cracks may be detected by Magnaflux methods but there are others which only develop when the surface of a ground component is etched and so, unless a works is provided with means for detecting these defects, the components may go forward into service and fatigue failures develop from these minute defects.

There is a tendency to lobing or chatter on ground cylindrical components and this is particularly evident on components which have been centreless ground. The lobes are always odd in number and are not discernible by two point measurement, but may be measured by three point methods or by blue marking checks. A characteristic waviness is produced by grinding which is small in height, but has been noted to have wavelengths varying from 0.01 - 0.1 (W. E. R. Clay, of Rolls-Royce, also reports this).

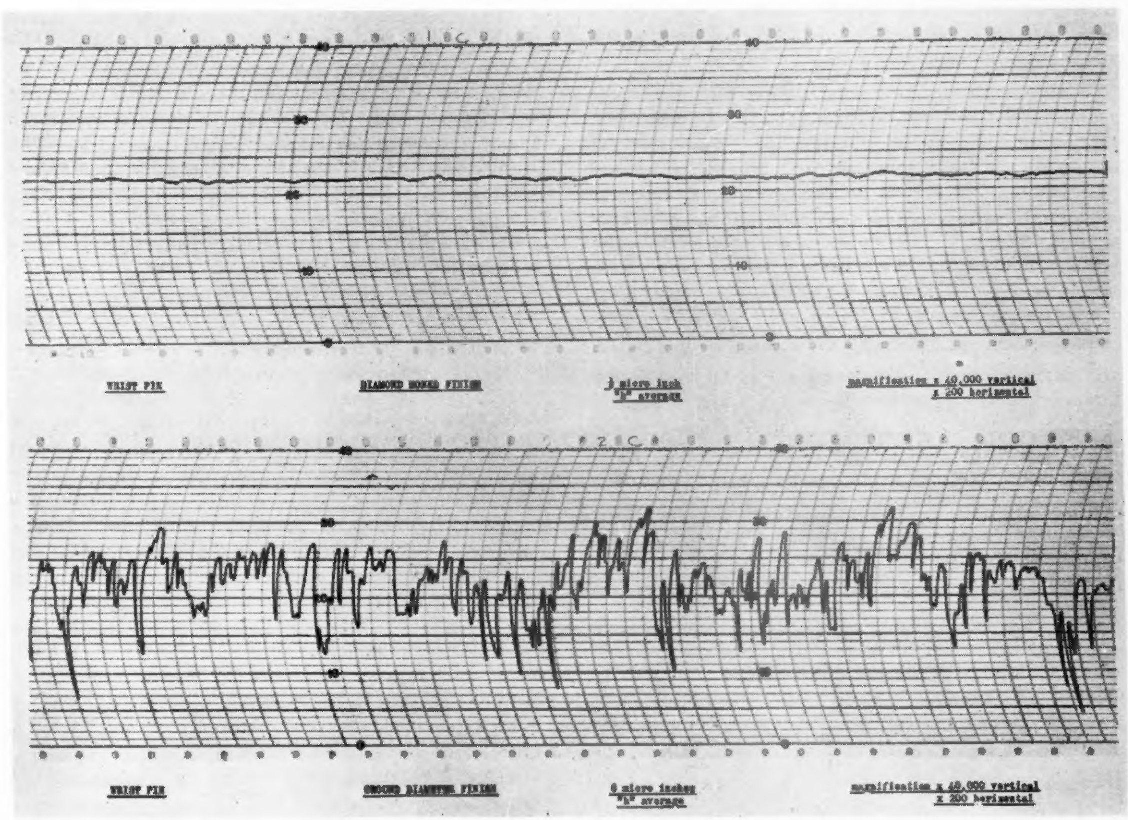
It has been found that under certain circumstances grinding will produce zones of unstable austenite on the surface. This has dire effects on fatigue resistance and on one occasion was found to be the cause of surface breakdowns of multi-lobar cams which had hitherto been manufactured for some years without subsequent service failure.

An inevitable result of grinding is the formation, as the result of the high heat generated at the wheel to work contact line, of an extremely thin surface layer of decarburised material. This has to be removed by a running-in process before a really satisfactory bearing is obtained and has been found to be most disadvantageous to rubber and synthetic rubber oil seals.

Honing

Most of the disadvantages noted in connection with grinding may be either removed by honing or avoided by a suitable combination of the two processes.

Properly designed hones with carefully selected



Figs. 1 (bottom) and 2 (top).

honing strips are capable of reproducing a desired finish over an almost illimitable number of components with a dimensional and geometric control of considerable accuracy.

The surface "fuzz" produced by grinding may be quickly removed without the production of some other undesirable condition, the material being removed with a negligible rise in temperature. Unstable austenite mentioned in the remarks on grinding is also eliminated and by a combination of good quality open grinding and final honing, components are regularly being produced to within .0002 inches diametrical variation from piece to piece, 1 to 2 1/100 of a thousandth ovality and a surface finish of less than $1\mu''$ C.L.A.

Figs. 1 and 2 are the Talysurf records of a component which was ground to an average finish of $8\mu''$ C.L.A. and then honed to remove the grinding fuzz and produce a finish of $\frac{1}{2}$ - $1\mu''$. These graphs are not true records of the surfaces, as in the original the vertical magnification is 40,000 and the linear X 200, giving a distortion ratio of 200 : 1.

Parts which have been nitrogen hardened react well to honing. As a rule it is possible to finish to size before nitriding and to hone afterwards to correct any treatment growth and remove bloom. The process does not crack the surface and does not destroy the advantages of nitriding.

Components may be honed to size and to correct geometric shape before nitriding, and after completing the hardening process, running or fitting surfaces honed to correct growth, or just to remove bloom. The bloom may be left on non-working surfaces to advantage, as it provides some measure of protection against corrosion. It is considered a disadvantage to grind after nitriding as the surface is even more prone to grinding cracks than one which has been carburised.

The honing fixtures used by the Bristol Company are designed so that the position of the hones is under definite control. The hones are generally positioned by adjusting cones and to facilitate control, the component where possible is rotated and reciprocated in the fixture.

We do not associate honing only with finishes of low surface readings, but consider it rather as a process for the accurate removal of stock and for the correction of geometric errors on both inside and outside diameters.

Fig. 3 shows the section of the hone which was developed for honing the inside and outside of cylinder sleeves simultaneously and is used in conjunction with a vertical hydraulically operated machine.

Honing

The pressure necessary to operate the diamond impregnated honing sticks is supplied by a separate cylinder. The spindle carries a special adaptor or driver for accommodating the flange of the sleeve and permits a limited floating action, which enables the work to accommodate itself to the whole honing tool, which is fixed to the machine and remains stationary while the cylinder sleeve is given a combined rotating and reciprocating movement through the machine cylinder.

Fig. 3 shows the honing tools with a vertical hydraulic cylinder (a) for operating the internal honing mechanism arranged above it. The cylinder (a) is surrounded by a sleeve (b), which carries the honing arrangement for the external diameter. The piston rod of cylinder (a) has an extension (c) to which the ring sleeve (d) is fixed by means of a screw plug (e). Two conical rings (f), carried by sleeve (d), are spaced by a distance sleeve (g) and are held in position by an end plate interposed between the rings (f) and the segments (j) which carry the diamond-impregnated honing sticks (m). For the internal diameter two rings of steel balls (h) are provided. When the sleeve (d) is moved upwards under the action of hydraulic cylinder (a), the rings (f) exert a wedge action on the hone segments which is transmitted through the balls to the honing sticks so that they engage with the work.

The honing sticks for machining the external part of the cylinder are operated by three smaller hydraulic cylinders (k) spaced at equal intervals around sleeve (b). The combined cross-sectional area is equal to that of the single cylinder (a), so that the pressure generated inside and outside is the same. The piston rods of the three cylinders are connected with the ring-shaped housing (l). Inside this housing two conical rings are provided which again, through two rows of steel balls, apply a radial movement to the external honing segments. The conical rings are again spaced by a distance sleeve and are secured in position by a disc. The external honing tool consists of three segments each carrying six diamond impregnated honing sticks, whilst the bore is machined by 18 diamond honing sticks. The hydraulic pressure of 100 lbs./sq. in. is controlled by a single lever. Two relief valves are provided for independent adjustment of the internal and external pressure, the actual pressures being indicated by gauges.

The cylinder sleeve fixed to the honing machine cylinder is rotated at 50 r.p.m. and performs 30 - 40 reciprocations per minute. The diamond honing stick removes 0.0005" of material in a machining time of between three and six minutes, either bakelite bonded sticks or metal bonded sticks (brass) being used. With a diamond grain of 150 mesh, a finish of between 12 and 15 micro-in. average height is obtained in production. The lubricant consists of a mixture of paraffin and lard oil in equal volumes, but for a larger stock removal the percentage of paraffin is increased. The lubricant is pumped from the sump located in the base of the machine to a centrifuge for cleaning before being passed to the job.

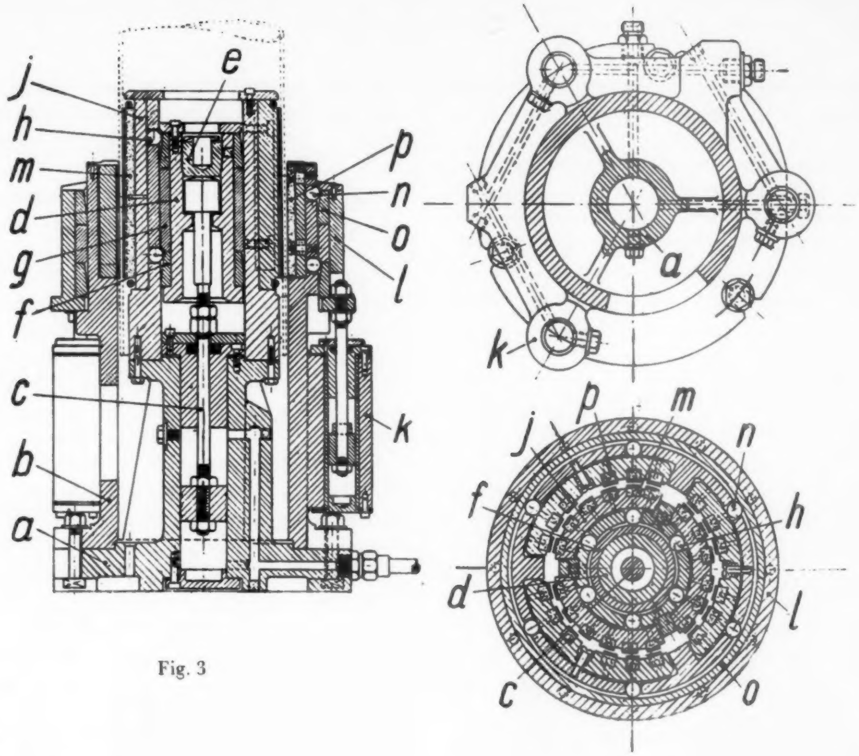


Fig. 3

Fig. 4

From 1,000 to 1,500 cylinder sleeves can be diamond honed before the sticks need to be replaced.

For reducing idle time, two adaptors or drivers are used with the machine so that while one of the drivers is being used, the other may be unloaded and reloaded. The finished sleeves are checked for external and internal diameter with Solex air gauging equipment, and a percentage checked for maintenance of surface finish.

This description concerns itself with the most complicated hone used in our works, but many others have been developed for various jobs demanding accurate dimensional control.

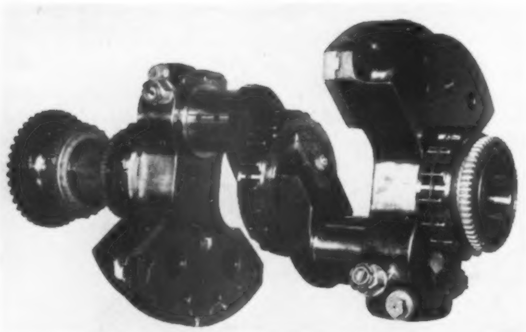


Fig. 5

Generally the operating cones are manually impelled and in one instance for dealing with the bearing track in a small gear, provision is made to trip the hones over the shoulders.

The method known as "Super-finishing" is useful where controlled hones cannot be applied, such as between deep shoulders. It supplies a great deal of surface roughness control but very little in the correction of geometric errors; the random movement of the surfacing stone providing a finish similar in nature to that of honing.

Lapping

Lapping as a process covers a wide field of application, from the preparation of joint faces and the provision of roughened surfaces for specific purposes down to the fine technique for the production of slip gauges. It is generally performed using an abrasive paste or powder in conjunction with shaped or flat laps, or lapping two components together to obtain intimate contact.

In our business we do comparatively little lapping of steel. Of the two main instances, both are concerned with the provision of an adequate grip between two cylindrical surfaces. In the first case, it is required to shrink fit the main bearing sleeve on to the nitrided crankpin shown at top centre of Fig. 4 and it has been found advantageous to provide the crankpin with a matt lapped surface of about $10\mu''$ to assist in preventing the sleeve from turning. Both ground and honed surfaces were tried and found unsuitable, but the fine granular surface formed with a cast iron lap and a fine lapping powder produces most satisfactory results. It is interesting to note that it has been found necessary to provide the bore of this bush with a phosphate coating to reduce a tendency to fret. The surface of this coating varies from $80\mu''$ to $100\mu''$ R.M.S.

Fig. 6

This class of lapping treatment is considered to be successful only when applied to components which

are already geometrically correct, as little or no geometric control can be exercised without recourse to special techniques and equipment.

One other main application is most interesting and concerns the control of the grip of a clamped joint as seen in Fig. 5. It has been found that the tightest grip of such a joint is obtained by providing the finest finish on both surfaces combined with the most complete coincidence in shape. A great deal of time has been spent in developing the technique of lapping these two components together and determining the optimum diametrical fit, together with the shape and amount of local relieving.

The two components are assembled after the application of the necessary lapping compound with some degree of nip and lapped in the normal way by rotation and periodically examined until an even marking is obtained. Both bore and shaft are then polished with crocus paper to produce a fine surface of approximately $\frac{1}{2}\mu''$ from a lapped finish of $2\frac{1}{2}$ - $3\frac{1}{2}\mu''$ C.L.A.

Then follows what is perhaps the most important step. Both surfaces are washed absolutely clean with water-free trichlorethylene and surgical lint and the joint assembled without delay, the pinch bolts are pulled up to the required degree of stretch and the joint thus completed. This provision of 100% contact, free from even the thinnest separating film of grease, has been found to provide a joint which will withstand the torsion of 3,000 B.H.P. on a shaft some $2\frac{1}{2}''$ in diameter.

Either of the surfaces may be hardened, in fact, in this case the shaft is nitrided, but when both are hardened the grip is considerably reduced.

Both these lapping processes which have been mentioned satisfy Rule 1 which was postulated, but being essentially hand operations fail on Rule 2.

Polishing

To provide smooth changes in section, to form radii on corners, and remove machine marks in order to avoid unnecessary stress concentrations, probably calls for more polishing of components in the aero-engine world than in any other industry. This polishing is generally of a precision nature and demands that the operators work to gauges for size and radii.

We are not here to discuss the comments of the polisher used to decorative work when introduced to our class of work, warming though they may be, but it has been necessary to develop a technique and a frame of mind in our polishing shops in order to obtain the finishes and dimensional control which we require.

Continuing with steel components, polishing is carried out on those surfaces where grinding would not be profitable or in most instances practicable and a finish of 3 - $5\mu''$ is the usual sort of result.

Generally a high gloss is not aimed at, but rather a smooth, scratch-free surface is desired. High polish in any event tends to set up undesirable material conditions near or on the surface of the component. To remove the effects of local heating during polishing, it is a general practice to effect a heat treatment. On most steels one hour at 180°C. is effective.

The radial engine connecting rods shown in Fig. 6 are polished all over to produce the desired surface and to form the edge radii so necessary to maximum fatigue resistance.

Light Alloys

To turn to light alloys, components made in these materials are, with a few exceptions, not made to extremely close tolerances. The materials generally do not hone well, as there is a great tendency to clog the hones and grinding is not entirely favoured. To produce good finishes with dimensional control to reasonably fine limits, in some instances to ±.0005″, diamond turning and boring on suitable high speed machines has been developed and in special applications finishes as low as 3 - $5\mu''$ C.L.A. are regularly produced.

Ordinary turning on joint faces up to some 3 ft. in diameter, with widths varying from $\frac{1}{2}$ - 2″ using tipped tools, are commonly found to be 20 - $30\mu''$ C.L.A. Where absolutely necessary such faces are lapped by fitters to remove distortion and provide oil tight joints, a very important contribution to the reduction of fire risk in aircraft.

The exteriors of castings are invariably polished to provide good enamelling surfaces, and to provide for the ever present need to avoid stress concentrating sharp corners and changes in section. The instance of one major supercharger casing (see Fig. 7) comes to mind, where the radiusing and smoothing occupies a great deal of time, and such is the severity of its operating conditions that upon the quality and general goodness of its surfaces depends largely its

Fig. 7

freedom from fatigue failures. The crankcase sections (Fig. 8) are machined practically all over from light alloy forgings, and the diaphragm surfaces are finally polished to provide smooth continuous surfaces and produce the necessary generous radii around the edges of the various communicating holes in them.

These light alloys, particularly those which are mainly magnesium, demand a great generosity of radii in fillets and the importance of imparting a smooth surface to those radii where stress may be concentrated cannot be over-emphasised.

Bearing Materials

Bearing materials fall largely under the same heading, as far as methods of machining are concerned, and fine diamond or tipped tool turning and boring to finishes of 5 - 15μ″ C.L.A. are generally satisfactory.

The quality of a bearing bore as well as the degree of surface finish depends considerably on the design and condition of the machine and its associated equipment. The finish of the surface is largely dependent on the form of the cutting point and in the case of diamond tools may involve some trial and error in setting the tool, even using a microscope to obtain the best result. The use of diamond tools with a lapped radius, instead of merely blended facets, is of great help and reduces the trial and error process to a minimum.

The general quality of a bore and to some extent the microfinish is also dependent on the freedom of the spindle from vibration, and general machine vibration which is excited by the various drives or even from external sources such as adjacent

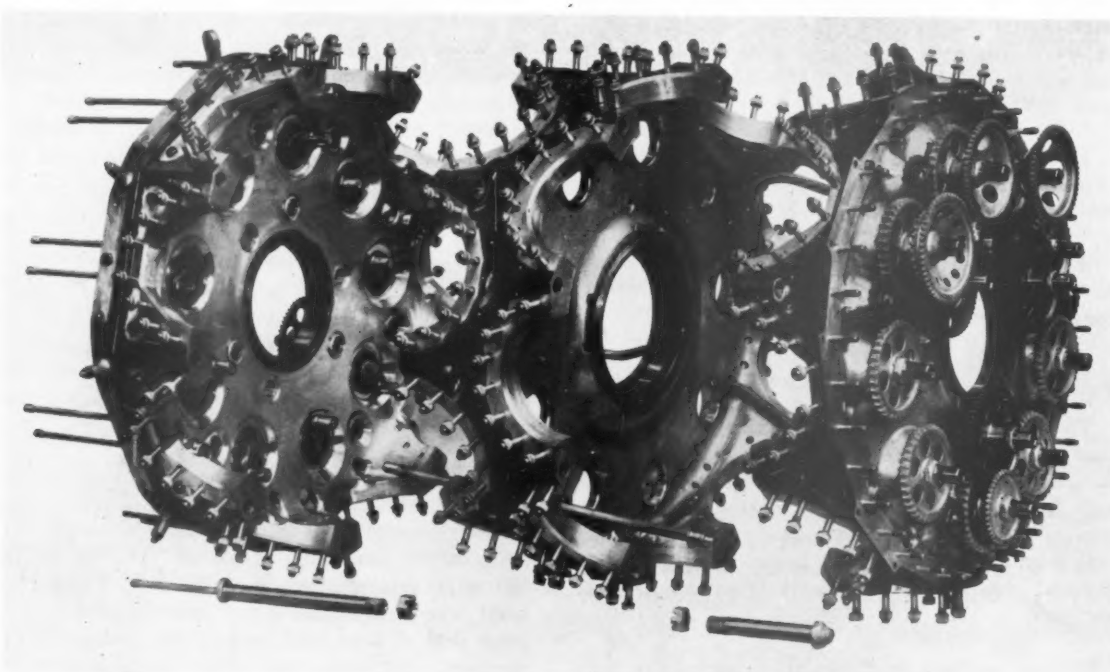


Fig. 8

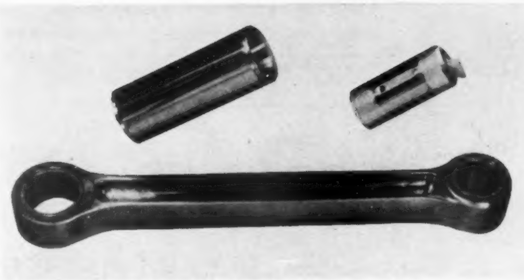


Fig. 9

machinery. The same comments also apply to fine turning and it has been found that with careful analysis of Talysurf graphs these sources of vibration can sometimes be traced and eliminated.

Fig. 9 shows a radial engine articulated connecting rod which presents two highly loaded bearings finished by two different methods. It illustrates the need for the development of special techniques for the provision of surfaces to withstand exacting conditions and shows that, because the use of such techniques is essential in one bearing, there is no need to spend time and money using it on the next one.

This steel forging is machined all over and finally polished to provide a smooth continuous surface free from scratches and is well radiused.

It is provided with two phosphor bronze bearings, the larger diameter one operating on a fully floating gudgeon pin in the piston and splash lubricated and the smaller one on a fixed wrist pin in the master connecting rod and is pressure lubricated.

Both bushes are initially diamond bored on a special two-spindle machine to a finish of around 6 - 8 ″ C.L.A. The speed of the boring bars is 2,000 r.p.m. with a feed of 2″ per minute.

In the case of the wrist pin bush, the normally good bored finish was not found good enough to satisfy the green running requirements and some further treatment is necessary to give it a good start in life.

After boring to the normal finish $6 - 8\mu''$, the bush is roller burnished. This operation consists of lining the bore with a crowded set of rollers and passing through the centre a bar with a slow taper, so that as the bar proceeds an increasing pressure is transmitted through the rollers to the bush. In this particular case there are 18 round ended rollers, each 4 m/m. diameter, $1\frac{1}{2}''$ long, in a bearing bore 1.128 + .0005″ diameter. The bar has a taper of .0015″ on diameter over a working length of 7″, with a portion of additional taper at the leading end to facilitate entry.

When fully engaged the size of the large end of the bar is such that an interference of from .001 - .0016″ is imparted to the bush. Most of this is absorbed in the elastic expansion of the bush and rod eye, with only a small permanent change in the size of the bush bore.

The fixture which locates the component is provided with caps to take the end thrust of the rollers and the operation is fully mechanised. A $\frac{1}{8}''$ H.P. motor is geared down to rotate the tapered mandrel at 100 r.p.m. and, having entered the bar, feeds itself through unaided by any axial loading. At the end of its travel, the direction of rotation of the bar is reversed and it winds itself back again. The component is then turned over and the process repeated from the opposite end, the whole operation occupying about $2\frac{1}{2}$ minutes. During the process the rollers are lubricated with a flow of finely filtered castor oil.

The finish resulting from this roller burnish is from $1\frac{1}{2} - 3\mu''$ C.L.A. and it is considered that the benefit received is due more to the increase of the initial bearing area, than to any work hardening that may have resulted from the pressure of the rollers.

Talysurf graphs of the two surfaces are shown in Figs. 10 and 11. They were recorded from precisely the same positions on a bush before and after roller burnishing and, as will be observed, all evidence of the machining has been removed. The introduction of this process reduced green failures of the bearing by a remarkable degree, but did not entirely eliminate the trouble. The ground surface of the hardened pin upon which it operates was therefore studied and reductions in roughness by grinding did not bring about any notable improvement.

Controlled honing was introduced and the surface honed to $.5 - 1\mu''$ C.L.A. and such is the success of the combination that the slightest warming of one of these units is subject to comments and investigation.

Thus we have brought together two surfaces with low surface readings and which are geometrically good, and produced a bearing which is sound. In one instance, the surface was smoothed without stock removal and in the other, the surface normally removed by "running-in" was honed away leaving a clean smooth one.

It has not been found or considered necessary to pay any special attention to the bore of the bearing in the other end of the rod, as the diamond bored finish is quite satisfactory.

Reducing the Risk of Fatigue

The third item in Fig. 9 is the gudgeon pin and being a reciprocating part has to be designed down to weight, and thus is thin in section. Every advantage has been taken in design to make it thicker in the centre than at the ends to keep it as stiff as possible.

The outside diameter is centreless ground and then honed to correct the geometry and provide a good bearing surface and until recently, the bore was ground to a commercial finish of $40 - 60\mu''$ C.L.A. Examination of the fractures of pins which failed on overload tests showed fatigue to be present, the nucleus in each case to be at the bore surface. As a result two actions were taken to correct this trouble. Advantage was taken of the compressive stress set

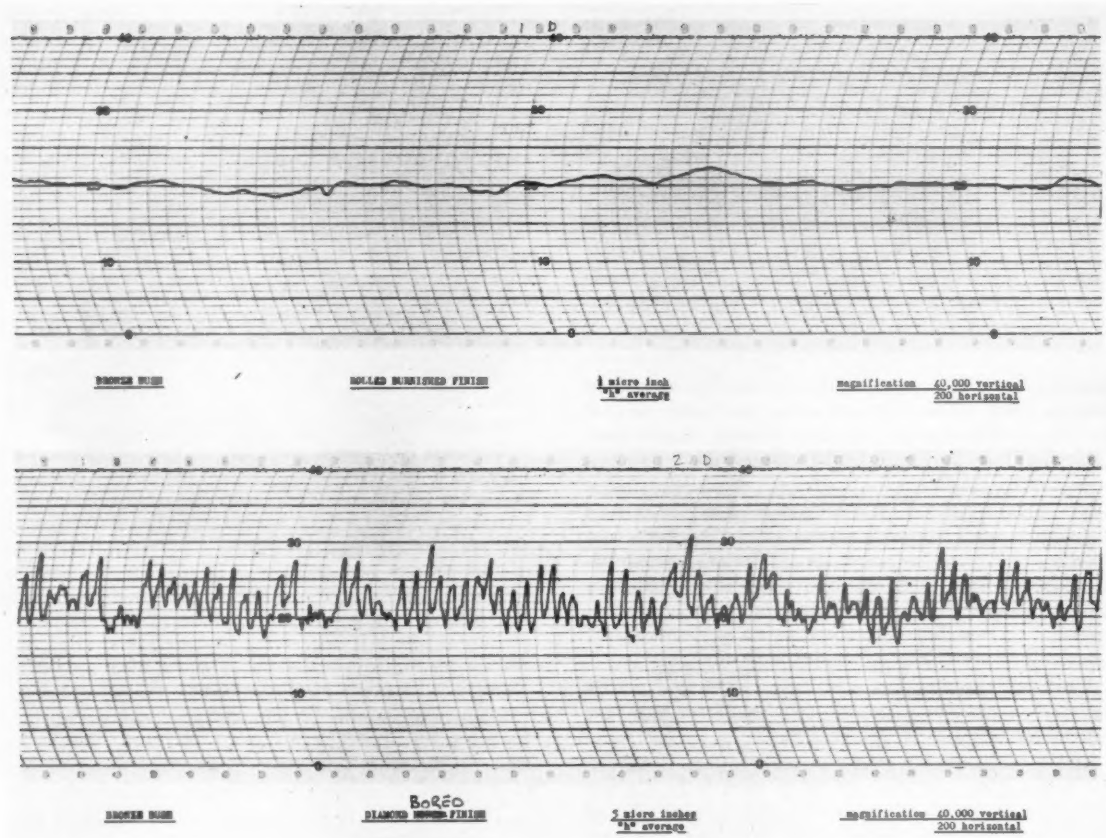


Fig. 10 (bottom) and Fig. 11 (top).

up in surfaces by nitriding and at the same time the maximum finish in the bore was set at $10\mu''$ C.L.A. Thus we have an instance where finish and surface treatment was modified solely to improve the fatigue resisting properties of a component.

Turning to other methods of finishing, some consideration must be given to grit or shot blasting and tumbling. These provide a means for the removal of surface material under low temperature conditions, and are generally used for cleaning purposes or for improving surface appearance, but they have important advantages in improving the physical condition of the material.

This improvement is due to the removal from the surface of undesirable material conditions which may otherwise have been a source of weakness.

The instance was previously mentioned of the failure of the surface of multi-lobar cams due to the formation of unstable austenite. This was successfully broken down by shot blasting and the surface left in a smooth enough condition for successful operation of the roller followers.

There may also be a direct contribution to the improvement of the material condition by the creation of a surface compressive stress.

From this aspect, tumbling is not of great importance and cannot be used conveniently on important parts of awkward shape or appreciable mass. Small parts of more regular shape can be usefully tumbled, being made to hammer direct on each other or mixed with balls whose number and size will be proportional to the component being treated. The removal of burrs and sharp corners using abrasive chips instead of balls is in greater use in America than in this country and the appearance of parts so treated is good.

Parts which may sustain the greatest benefit from surface bombardment are usually best blasted with shot and to give the process some standing, the term "shot peening" has been used. Usually a test strip is treated at the same time as the component and the blasting stopped when a pre-determined radius has been formed. It is important to ensure that no broken shot is used, as the surface may become seriously marked with sharp indentations which would favour the very type of component failure at which the process is aimed.

The failure of most components under service conditions is associated with fatigue which originates at some point on the surface. All failures may be

said to be tensile failures and thus the provision of some surface compression is of value in reducing the tendency to failure.

It has been already stated that surface bombardment provides a measure of this condition and nitriding is most effective. Carburising in a lesser degree has some effect, but the temperatures involved and the surface condition after treatment make it unsuitable for components finished to size. Nitriding, on the other hand, involves the component in very little distortion and due allowance may always be made for the characteristic dimensional increases. Its great disadvantage is the time taken for the treatment and the complexity of the equipment involved. One point, however, is common to all treatments introducing surface compression: no damage to the surface in the form of sharp nicks or cuts can be tolerated once the treatment has been applied.

Previously it has been stated that grinding produces a "fuzz" which is best removed from bearing surfaces and the characteristic spots of local overheating severely reduce the fatigue resistance of a component.

The effect of varying surfaces and methods of machining on the fatigue limit of a component is interestingly demonstrated in the results of some work carried out on S.11 steel studs, whose threads were produced by various methods and subjected to various surface treatments.

It was found that the greatest resistance to fatigue was given by three methods of production, namely: (1) die cut threads; (2) shot blasted automatic feed plunge ground threads; and (3) shot blasted rolled threads produced from blanks of the correct diameter.

The poorest results were obtained from (1) through grinding; and (2) rolling zinc plated blanks.

In order to extract the utmost advantage from the knowledge gained, the studs made by rolling cadmium plated blanks of the correct size were decided upon. These, as will be seen in Table 1, are only slightly lower than the maximum for fatigue limit, but the thread flank surface so produced was found most suitable for controlled nut tightening and the cadmium still remaining at the surface provides sufficient protection against corrosion.

Reduction of Wear

The development of a surface which will give maximum life with minimum wear is perhaps best illustrated if we trace the history and development of bores in which pistons work. The ultimate result of many years of work is depicted in Fig. 12, which shows the sleeve of a modern sleeve valve engine together with its piston and cylinder.

To start from the beginning, at one time we produced a poppet valved engine with a steel cylinder (Fig. 13) and, as with all types of radial engine, the people of the day were beset with master piston troubles.

They prided themselves on the excellence of the quality of their cylinder bores and exhibited to all comers the peculiar effect of peering into a cylindrical mirror. The work that went into producing such a finish was tremendous, but how much fuzz and surface tension was produced is a matter for conjecture. One thing is certain, piston seizures on master pistons were a serious trouble.

The measurement of surface finish was not possible in those days, but one can safely assume that the figure for the cylinder bores was around $2 - 5\mu''$ C.L.A.

Piston diameters were ground, that being the most accurate and stable means available, and it was found that considerable benefit was obtained by rubbing the skirts with pumice powder in an axial direction. It is thought that the operation probably removed a layer similar to that formed on steel and was thereby a good thing. We are not troubled with such a surface now, as pistons are diamond turned to a finish of $8 - 10\mu''$ C.L.A. on the skirts and their gudgeon pin bores diamond bored to $3 - 4\mu''$ C.L.A.

Oil consumption was not the least of the troubles in those days and its control was difficult.

The introduction of a honing machine enabled

TABLE 1

Method	*Surface Treatment*	*Fatigue Limit ft./lbs.*
Die cut	Nil	.12
Through grind	Nil	.07
Plunge grind hand controlled	Nil	.08
Automatic feed	Nil	
Plunge grind	Nil	.08
Automatic feed	Shot Blasted	
Plunge grind	and Cosletised	.12
Rolling of machined blanks to correct diameter	Nil	.08
Rolling of machined blanks to correct diameter	Shot Blasted	.12
Rolling, zinc plated blanks	Nil	.07
Rolling, cadmium plated blanks of correct diameter	Nil	.11
Rolling, cadmium plated blanks .004 - .006" oversize		.08

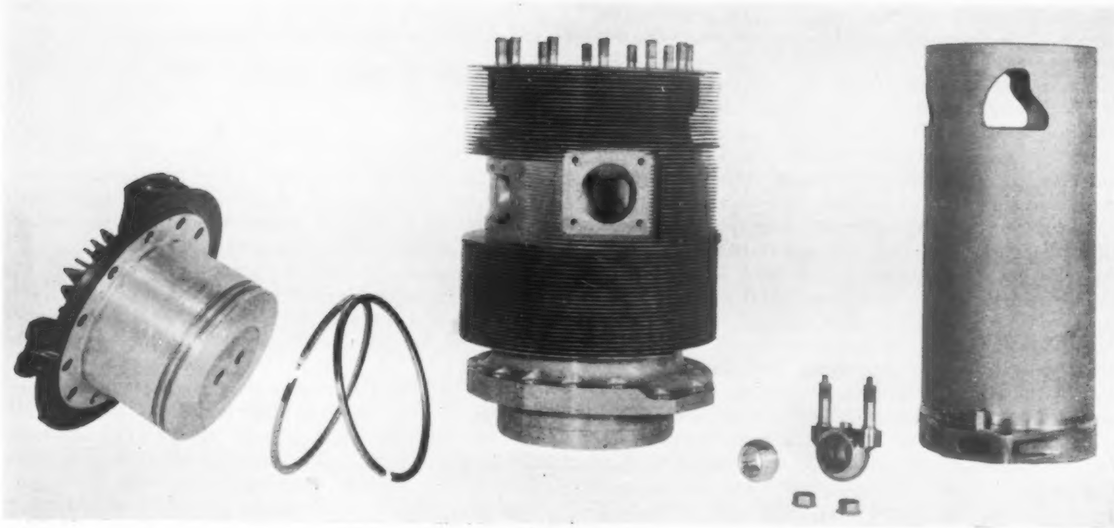


Fig. 12

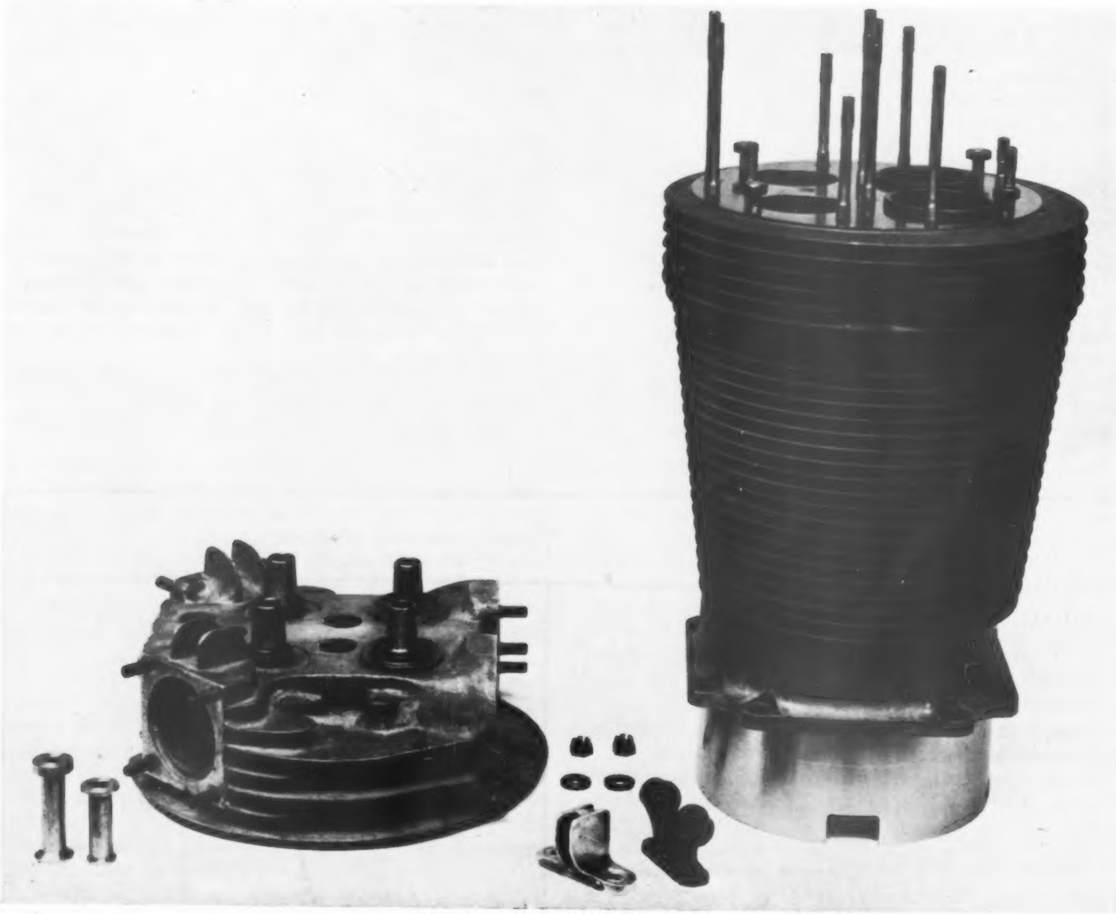


Fig. 13

cylinders to be produced with more geometrically correct bores than hitherto, but some trouble was experienced with scratched and worn pistons.

Lapping, it was thought, would take the harshness out of the honed surface and provide a matt oil-retaining surface and so, using fine cast iron laps and F.1. carborundum powder, this was proceeded with. This we now know gave a finish of around 35″ R.M.S. and was not fine enough, therefore a final lap using bull neck hide laps and Allundite 240 powder producing a finish of some 15 - 20″ R.M.S., was introduced.

This method continued with minor variations to counter various difficulties as they arose throughout the introduction of nitrided bores and up to the introduction of sleeve valves, with considerable success.

The hones then used were not of the controlled type which has previously been described, but were spring loaded and carborundum or other abrasive stones were used.

The sleeve valves of engines, besides requiring the same degree of excellence in the piston bore, demand also control of their outside diameters and it has been found that approximately the same degree of surface texture is required for both inside and outside surfaces.

Sleeves are made from a high expansion steel, which is not a good nitriding steel, and nitrided all over by a specially developed double treatment process.

At one period when sleeves were wanted quickly and in large quantities oil consumption and green seizure troubles developed with an increase in power.

A close examination of the shape of a sleeve showed that a relatively large degree of corrugation existed, which was no doubt a relic of the centreless grinding process. This final grinding is more of a rounding operation after nitriding than a sizing operation, but nevertheless the characteristic chatter as shown in Fig. 14 tends to develop. Further examinations and measurement of the surface of sleeves which had run and would continue to run satisfactorily were carried out and, as a result, sleeves which were as near perfect tubes as possible and with a surface finish of around 2 - 3μ″ were produced.

These failed, due mainly to excessive wear, but nevertheless the idea of the perfect tube was retained and obtained by using diamond-impregnated honing sticks, but the old system of lapping to give a ring bedding and oil bearing surface was re-introduced with some variations. This lapped surface was produced with cast iron laps and paste to a finish of 35μ″ C.L.A. but was a little too harsh, and was finally followed with a smoothing process which we now call Satin Finishing.

This is an interesting and unusual operation. The sleeve is held vertically and stationary while being surfaced by brushes and abrasive powder. The brushes are held in a sort of lapping tool to operate simultaneously on the inside and outside surfaces and rotated and reciprocated over the surface of the sleeve at 65 r.p.m. and 40 strokes per minute for two minutes.

Fig. 14

During the operation a mixture of Albo grease, brushing and flour emery, thinned with lard oil, is freely applied.

The surface obtained is pleasant to touch and has a kind of lustre to it, with a surface reading which is held within 20 - 30μ″ C.L.A.

The Talysurf graphs (Figs 15, 16 and 17) show the development of the surface from grinding to final satin finish and illustrated also is the surface of a sleeve which has run for a considerable time.

The development and rapid expansion of civil flying since the War has brought a demand for longer and longer overhaul life and as with all forms of piston engine, bore wear was one of our biggest headaches. This was initially overcome by honing worn bores round and parallel, re-nitriding and re-processing, but on a thin sectioned highly stressed component such as this, re-processing has a very limited extension factor.

Intensive work by laboratory and machining technicians has produced a sleeve which is nitrided twice, and which has a deeper and less brittle case which is more resistant to wear and less liable to surface flaking than has previously been possible. This sleeve is surfaced in the same way as its earlier types and is giving excellent service.

To assist in the initial running stages it has been found advantageous to coat the sleeves with a colloidal graphite compound.

Throughout all this, the surface of the light alloy cylinder has not been lacking attention. It is normally bored on a Heald borer with a tipped tool to a finish of 10μ″ C.L.A. The bores are found to be good geometrically and are smaller in the centre at hottest running zone than at the ends to give an approximate parallel bore under operating conditions.

After boring they are polished with felt laps on a K & W machine to a finish of 3μ″ C.L.A. The felt laps are dressed with a polishing mixture which consists of Albo grease, polishing composition, finishing composition and No. 90 London Emery Powder, and are driven at 400 r.p.m.—60 strokes per minute for 4 minutes.

It has been found essential to treat the bores with a corrosion preventative immediately after polishing to prevent deterioration of the surface due to oxidisation.

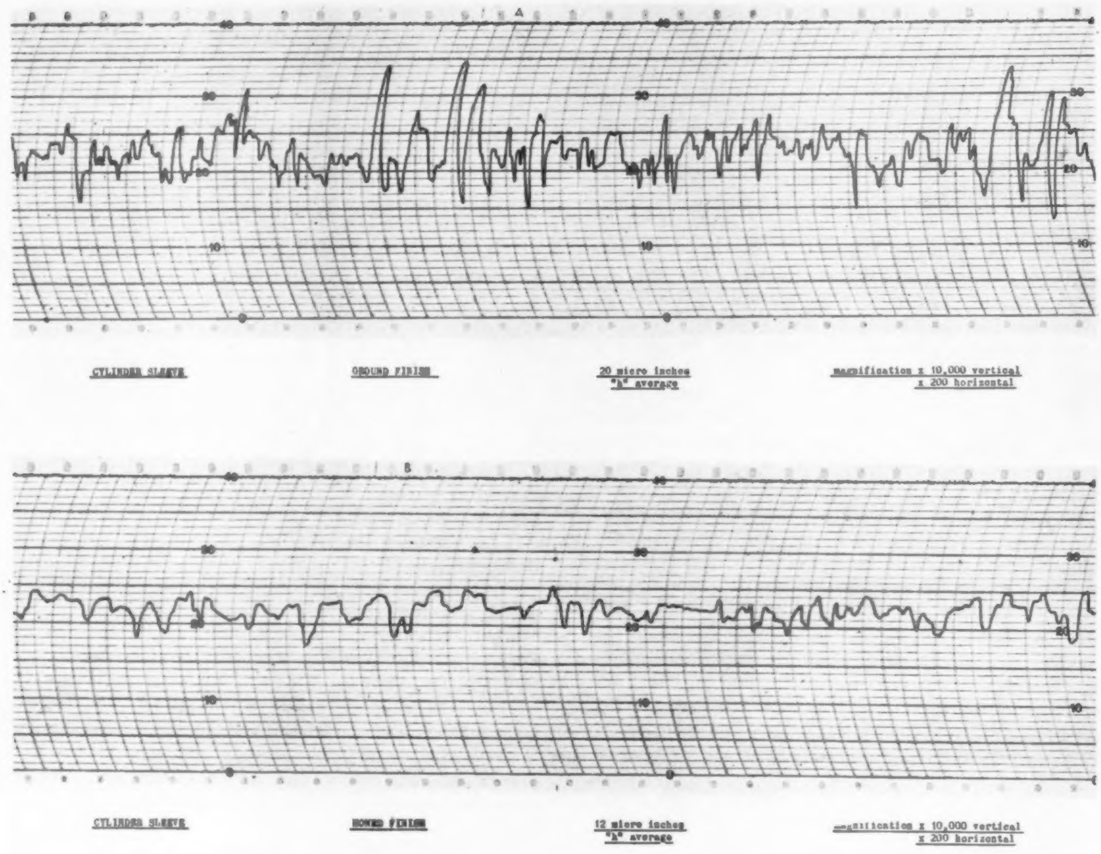


Fig. 15 (top) and 15(a) (bottom).

Thus it may be said that the rules we laid down for engineering surfaces have as far as possible all been met in relation to cylinders and sleeves.

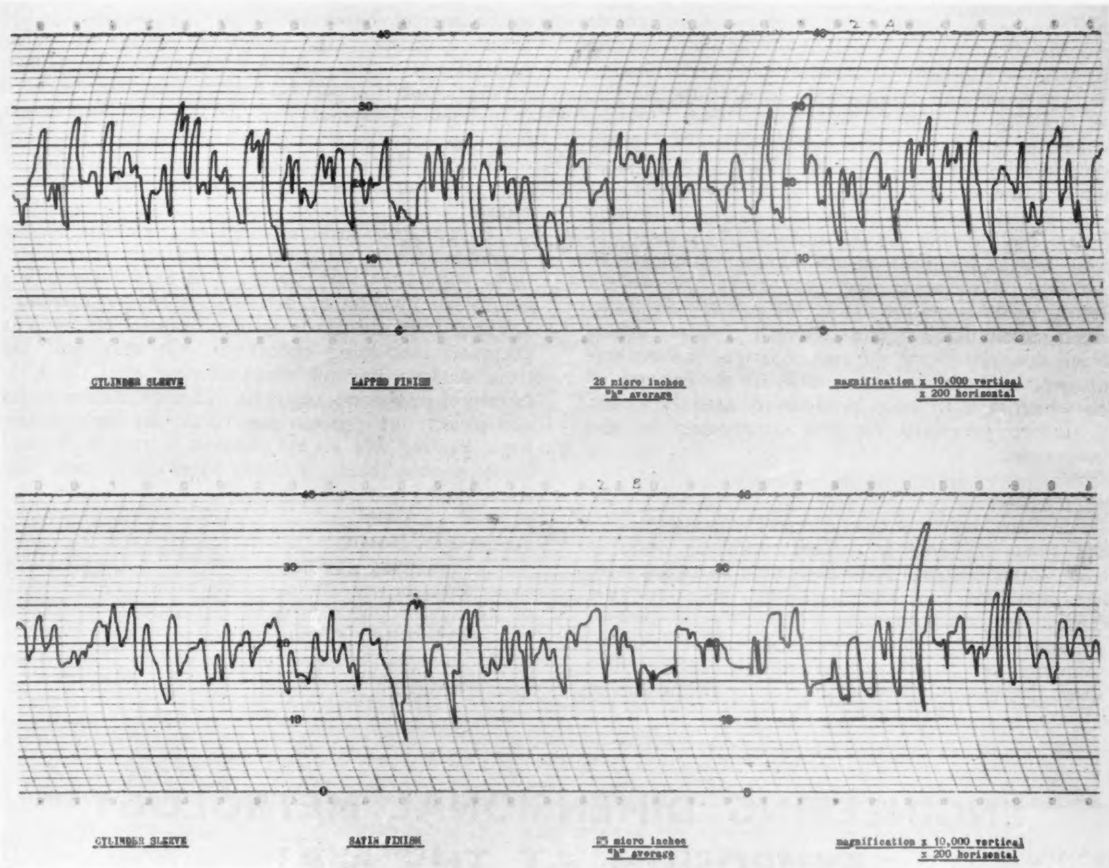
Prevention of Corrosion

The final rule which we set ourselves was to select surface treatments or coatings necessary to protect the part from the effects of fretting and corrosion which may be harmful to its function in life. We have seen in the subject of a main bearing sleeve that its bore was phosphate treated to prevent fretting which occurred when the bore was left untreated. Quite often, this matter of the prevention of fretting can be overcome by lubrication only and is therefore not a subject for discussion in this Paper. The fretting which occurred in this instance was of that peculiar variety which occurs where there is little relative movement and produces a rust-like deposit of iron oxide. The phosphate coat proved most satisfactory and its application to the bore was one of convenience, but in view of the tendency for this class of coating to reduce the fatigue resistance of the components to which it is applied, it would in this instance not have been applied to the crank pin even had that been the most convenient component to which to apply the treatment.

The internal parts of most types of internal combustion engines are subject to corrosion during shut down periods, and as corrosion is likely to set up conditions conducive to fatigue failure, some action has to be taken to prevent its development.

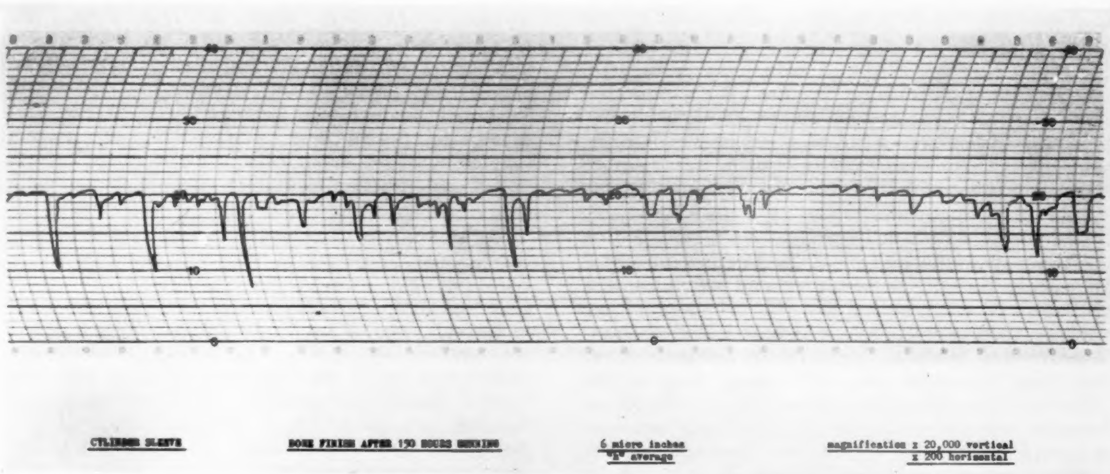
Most forms of electro-plating produce conditions of surface stress which are undesirable and therefore cannot be safely applied to highly stressed components. Tin plating is likely to penetrate into steel and set up undesirable metallurgical conditions and is therefore also inadmissible. For a long time we were faced with periodic internal examination of engines in storage, special lubricating cycles and sundry other expensive and lengthy treatments, but finally a special varnish was developed with which all non-running surfaces of the interior of our engines are sprayed, where the temperature conditions will permit its use. This varnish does not effect the fatigue properties of the components to which it is applied, and effectively prevents corrosion from taking place.

There are occasions when a decision has to be



40
30
20
10
0
CYLINDER SLEEVE
LAPPED FINISH
28 micro inches
"h" average
magnification x 10,000 vertical
x 200 horizontal
CYLINDER SLEEVE
SATIN FINISH
25 micro inches
"h" average
magnification x 10,000 vertical
x 200 horizontal

Fig. 16



40
30
20
10
0
CYLINDER SLEEVE
HONE FINISH AFTER 150 HOURS RUNNING
6 micro inches
"h" average
magnification x 20,000 vertical
x 200 horizontal

Fig. 17

made to decide whether the ill-effects of fretting on running surfaces are less desirable than the reduction in fatigue resistance introduced by certain anti-fretting treatments. One such example has had to be faced in relation to some large bevel gears in which the anti-fretting treatment, which had taken some long time to develop, was found to be a contributory cause to fatigue failures of the bevel teeth. We were, therefore, forced to accept a degree of fretting during the running on the surface of the teeth to avoid fatigue failures from the root, until alternative methods of surfacing the gear teeth to prevent fretting could be found. Thus, the rule we laid down which stated that we must select a class of surface which does not create the risk of fatigue failure, was satisfied, temporarily at any rate, at the expense of one which says, we must produce consistently a class of surface necessary for the functioning of the components.

Jet Engines

The introduction of gas turbines has brought in its train many problems of surface conditions, most of which fortunately we have been able to attack with the aid of the knowledge that was gained on the development and production of reciprocating engines. In point of fact, it is thought in general that the main problem is not production of suitable surfaces, but rather, the accurate production of some of the almost unimaginable shapes which are demanded by the aerodynamicists. The very high speeds at which turbine shafts rotate demand the control of surface finish in zones so near the neutral axis that not more than passing consideration would have been given had they been parts of piston engines, and we have been faced with grinding or extremely fine turning of very deep bores to reduce the probability of bursting failures.

The surface of turbine blades, or " buckets " as our American cousins call them, have so far been required to be of a very high standard of finish, which has been generally met by polishing or honing methods, working from the blade form generated in previous precision machining operations. It may well be, from the aerodynamic point of view, that the high degree of finish now required will not continue to be demanded, but it is envisaged that the high centrifugal loading will always demand a very high class finish on the blade surface, particularly near the root.

Acknowledgments

The foregoing comments have been based on the experiences of my Company, and represent the work of many people. I wish to thank those who assisted me in the preparation of this Paper and the Bristol Aeroplane Company for placing at my disposal the means for its production.

ENGINEERING DIMENSIONAL METROLOGY SYMPOSIUM AT THE N.P.L.

A SYMPOSIUM on Engineering Dimensional Metrology was held at the National Physical Laboratory, Teddington, from October 21st to 23rd, 1953. The Symposium was one of a series which it has been the policy of the Laboratory to arrange in their efforts to maintain regular contact with industry. It was timed to take place just before the retirement of Mr. F. H. Rolt, O.B.E., M.I.Prod.E., as Superintendent of the Metrology Division of the Laboratory. Mr. Rolt is well-known to members as the leading pioneer of Engineering Metrology in this country and, as he himself put it, this Symposium was his " swan song ".

Invitations to present Papers had been extended to a number of authorities in all fields of Engineering Metrology, both in this country and overseas, and 39 Papers were presented, of which 14 were from overseas sources, U.S.A., France, Switzerland, Germany and Sweden. Many of the delegates came from these countries also. Accommodation at the Laboratory was limited to about 250 and therefore delegates attended by invitation only; many members of the Institution of Production Engineers were, however, present.

The proceedings were opened on Wednesday morning, 21st October, by the Director of the Laboratory, Sir Edward Bullard, F.R.S. He was followed by Mr. Rolt, who gave an outline of the work of the Laboratory, and particularly of the Metrology Division, since its foundation. He explained the progress that had been made in the application of national dimensional standards to engineering purposes and described some of the instruments which had been designed at the Laboratory for this purpose. It was interesting to note that many of the early instruments were so basically sound and practical that they are still being made today and are widely used throughout industry.

Dr. D. G. Sopwith, Director of the recently formed Mechanical Engineering Research Laboratory at East Kilbride, near Glasgow, described how the M.E.R.L. had been started on a nucleus of certain sections of the N.P.L. In particular, a large part of the work of the N.P.L. Engineering Division and certain sections of the Metrology Division had been moved. Dr. Sopwith explained that building at East Kilbride was still going on and much of the equipment was at present temporarily housed, but that when complete the Laboratory would be adequately

(*continued on page* 597).

METHODS OF ACHIEVING MORE ECONOMIC PRODUCTION

A Symposium by

D. H. TURNBULL, M.I.Prod.E., L. RIGG, M.I.Prod.E., and H. CROMPTON, M.I.Prod.E.

Presented to the Yorkshire Section of the Institution, 9th March, 1953.

PART I

Mr. D. H. Turnbull

Starting as an apprentice with Geo. Mann & Co. Ltd., of Leeds, lithographic machinery manufacturers, Mr. Turnbull later became a draughtsman, development designer, and production manager.

In 1942, he was appointed Works Manager of T. S. Harrison & Sons, Ltd., and now holds the position of Works Director with that firm.

Mr. Turnbull is a member of the Yorkshire Section Committee.

THIS short Paper is more specifically relative to the small or medium-sized engineering shop and to batch production, rather than line production; such are the conditions in 95% of our engineering industry.

Effective economic production is the result of clear objective thinking and is no better than the quality of this thought. The starting point is the drawing office who design the end product such as the machine or equipment to meet a specific purpose, and this should be designed in as simple a manner as possible, keeping in view the manufacturing methods required as available. Even when the prototype is completed and functionally satisfactory to the designer and market requirements, production needs may require many detail modifications in order to simplify and cheapen the manufacturing processes. New techniques and manufacturing equipment may require further product detail modifications in order to make the maximum use of new equipment. Indeed, batch production has a decided advantage, since improvements can be made to the product from batch to batch, with the object of cheapening production and improving the product. Manufacturing costs from batch to batch will enable the works to see how far actual results have been achieved.

On the whole, the suggestions made here do not necessitate the buying of new equipment for the purposes of achieving economies, and can be put into operation immediately. It was originally suggested to me that I should give a Paper on copy turning but, after careful thought, I discarded this in favour of more commonplace material.

Using Existing Facilities

How often has it been said by various Productivity Teams that increased production can be achieved by better handling, less waste motions; that increased speed and feed could be put immediately into operation by operators working metal cutting machines. Such suggestions do not involve new plant or technique, but merely utilise the means already at our disposal.

It can be said that a workman is given specific instructions and should carry these out as laid down. Yet it has frequently been our experience that these results have been adversely affected by a broken tool, lazy handling and indifferent interest in the work involved. There is very often an underlying opposition to the management by their workpeople and this motivates their intentions and actions.

I am very sorry to say that I am convinced that in many shops output is governed to a very large extent by the workman himself, and the management very often takes a *laissez-faire* attitude towards this condition, with the possible remarks that this state of affairs will not change until there are ten men for nine jobs. This condition is, in my opinion, a reflection upon the management far more than upon the workman.

Importance of Leadership

Leadership today within the firm is as necessary as it has been at any time in the past, and it is the privilege and duty of the management, in the interests of both management and workpeople, to bring home to the workpeople that our future lies in effective team work, and that wholehearted effort by everyone concerned is necessary for our collective good. Management should be the guiding and co-ordinating influence in that team work, helping to solve difficulties and giving inspiration to all concerned. This endeavour certainly requires much patience, persistence, tact, courtesy and, to a certain extent, an indication that the greatest among you should be your servant.

As far as I can judge, America appears to give us a lead in the engineering industry by virtue of the almost entire absence of friction between management and workpeople, and there is no doubt that much closer contact, as a whole, operates there between workpeople and management. We are told by Productivity Teams, when comparing the American workman with his English counterpart, that more mechanised equipment is available to the American in every phase of his work. I myself feel that a more important aspect is the willingness to close co-operation. It is imperative that not only does the management have a right attitude to its workmen, but that the foremen understand and agree with this attitude and " put it over " to the workmen in their charge.

The following are the technical suggestions of what can be reviewed for purposes of improving the economy of production :—

Working Drawings

Are your drawings clear and distinct, so that no dimension or arrow-heads are doubtful ? Are they drawn handed as the operator machines the part, or has he to invert the drawing and read the figures upside down ? Are the dimensions arranged as the operator requires them, or has he to do some mental arithmetic in order to obtain some requisite information ? Is the drawing devoid of unnecessary figures or instructions ? Are the tolerances on the drawings as broad as can be allowed, and are the tolerances applied to the essential dimensions ? Are cumulative tolerances avoided where possible by an overall tolerance ?

Review of Materials Employed

Is the maximum use being made of the materials being used ? I know of one large firm making a full range of horizontal borers who use only four grades of steel. These are :—

1. Mild steel.
2. .4% carbon steel.
3. A nickel chrome molybdenum steel for gears.
4. Nitralloy steel for spindles and similar parts.

Each component using steel of one grade or another requires a review to see if cheaper material can be used satisfactorily for the required function. Freecutting steels such as sulphur and leadbearing are available in mild, carbon and nickel grades and, if the manufactured parts involve fairly heavy metal removal, the value of these steels in reducing machining time and prolonging tool life should be carefully considered against their slight increase in price. I have found these freecutting steels of great help, and suggest that you may also find them helpful. I would like to mention that it was suggested that leadbearing steels would not cyanide-harden effectively, but I have not found this to be the case and thousands of parts have been made in leaded freecutting steel and cyanided without any such difficulty attributed to a lead content. Is the maximum economy being made of bar material by using accurate collets in conjunction with bright drawn bar, and the avoidance of unnecessary reductions of bar material, as is frequently the case when using black bar ?

Inspection

Is your Inspection helping production as well as it may, or is it being too insistent on working rigidly to the drawing tolerances ? Is the Drawing Office combining with the Inspection Department when tolerances are queried, and an impartial decision made in the interests of working economy ? Good Inspectors should work more as advisers and friends to the workmen and foremen, rather than sayers of purely " yea " or " nay ". Inspectors whose background include Fitting Shop experience are a great asset to Machine Shop inspection.

Lighting and Ventilation

Is the workman being given the necessary conditions to avoid eye strain ? Are the windows cleaned regularly inside and outside ? Is the interior painted or distempered in as light a colour as possible, and is it done periodically, say annually? These conditions do have their bearing on output, as a man affected by eye strain is soon overcome by fatigue.

Castings

Does the quantity of castings warrant machine moulding with its high initial cost of hardwood or metal patterns, but cheaper prices and better quality? The foundry may have some worthwhile suggestions on the shape of the part, in order to cheapen the cost.

Use of Carbide Cutting Tools

Referring now to my own firm: we employ approximately 95% carbide cutting tools in our works, and there is no doubt whatsoever that we could not afford to do otherwise.

Breakages of carbide tools is the biggest factor mitigating against their more general use. Careful control of issue and replacement should be exercised, and grinding and honing should only be done by the toolroom. The honing of carbide tools is essential for that life which makes their use worthwhile. Diamond honing with a 400 grit diamond wheel prolongs the life of the cutting edge and is absolutely essential on fine boring to maintain size, required finish and maximum use between regrinds. Protective plastic covers for the cutting edges are now supplied with carbide tools, and when not in action, these should be replaced on the carbide tips. Correct use of the various grades should be carefully controlled and the grade, feed and speed stipulated when decided upon. Help on any application is readily offered by reliable makers, and their collaboration has been greatly appreciated by my own firm.

We use carbide milling cutters exclusively in our milling department, and all such cutters are issued from and returned to stores in wooden boxes with the cutting edges face downwards. It is part of the foreman's duty to see that any cutter not in use is placed in its box until required. Breakages of cutter teeth must be reported to stores and to the foremen. Breakages, even in dovetail cutters, are remarkably few, but to maintain this the machines must be kept in good condition and a strict routine in cutter use insisted upon. Special attention should be given to the register of carbide milling cutters and the grinding of cutters should be such that, when they are mounted upon their machine spindle, the out-of-truth error of the cutting edges be no more than .002″. Under these circumstances, the feed should be no less than .004″ per tooth. It is for this reason that we use teeth of slightly over 1 per 1″ of cutter diameter, so as to ensure that every tooth is cutting, and none of them rubbing. Adequate feed per tooth, within the capacity of the machine, is an insurance of good life between regrinds.

Work Planning

On all metal cutting machines it is worthwhile to consider multiple cutting and combined cuts, so as to reduce the actual cutting time.

When considering work to be planed, can a series of tools for stepped roughing and semi-finishing be employed in the tool boxes, and can more than one tool box be used for cutting simultaneously ?

Work being considered for turret or capstan lathes should be done on the possibility of multiple cuts, both in the hexagon turret and cross slide, and consideration should be given to how far simultaneous cutting can be done from these two positions. This also assumes that consideration is given to the maximum feeds and speeds that can operate under these conditions.

Surfacing work being considered for vertical milling machines by means of a carbide face mill should take into account the possibility of roughing in the direction of the trailing edge of the cutter, and finishing by a reversal of the table and an increased cutter speed, so that the trailing edge, in returning, removes approximately .001″ or .002″, and gives the necessary finishing cut in the minimum time.

When boring cored holes on the horizontal borer or Borematic, consider the use of a double-ended roughing-out tool and a finishing tool mounted on the same arbor and suitably spaced, so that there is no occasion for changing over from one arbor to another between roughing and finishing cuts.

Work Routing

Work routing should be flexible, so that work ahead of each machining section can be balanced as among the sections, as far as possible. For example, surfacing work on some jobs can be done on a planing machine, a milling machine, a shaper or even on a lathe and, whilst there is a section where this work can be done most economically, the overall economy is improved by placing work from that section to a less economical one as a temporary expedient. In a similar manner it is equally possible to bore some work on a horizontal borer, a centre lathe fitted with a boring table, a drilling machine or a milling machine. Where desirable, these alternatives should be indicated on the routing card, so that the route can be modified as is most expedient according to the work ahead of the various sections.

Gear Cutting

A recent development has been the increased output from hobbing machines, purely by increasing speeds and feeds to higher values. It has been found that high speed steel hob speeds can be increased to 275 ft. per minute, and the feed increased to .115″ per rev. of work, giving not only greater output but decidedly more gears between regrinds. Many hobbing machines may not be capable of giving these increased speeds but, where it is possible, the results appear to be beyond doubt.

Another hobbing machine suggestion, when the machine is fitted with axial hob feed, is the flycutting of phosphor-bronze worm wheels. A carbide tipped tool suitably shaped and placed on the cutting arbor in the correct position is given a fine cross feed in relation to the differential drive to the work arbor. The cutting arbor can be driven at as high a speed as can be obtained on the machine, and the resulting worm wheel has an excellent finish and a correctly developed form. This saves the cost of a hob and the delay in obtaining the hob if the delivery of the worm wheels is urgent.

Profile Turning Attachments

These attachments are now widely fitted to medium sized centre lathes, giving greater output by duplicating to templates, needing only the checking of one diameter where multiple diameters are involved, and maintaining accurate shoulder lengths, again copied from template. This attachment also serves a very useful purpose in screwcutting, enabling much higher chasing speeds to be used in cutting threads and avoiding damage to shoulders by arranging automatic withdrawal of the tool at a pre-determined point in the traverse.

Gear Splines, Heat Treated to a Workable Hardness

Economies of manufacture can be made by changing over to the new 30° pressure angle involute splines. The A.20 series of 6 and 8 spline shafts and holes, bottom fitting, may run concentrically true but can allow of appreciable back-lash. In order to eliminate this back-lash, ground splines are used, which grinding is entirely unnecessary if the involute form is used. With this form, the pitch diameter of the splines is varied to give the required fit in the broached hole, and re-sharpening of broach and hob can still result in fits as close as may be required.

Unorthodox Methods

It is definitely worthwhile to be on the constant lookout for unorthodox methods of saving time, and I have found workpeople very helpful in giving an indication on possible lines of action. I can recall two such instances :

(a) The simultaneous boring of five shallow apron holes from the solid, by carbide tipped drills, and the final sizing at the same pass by a carbide tool inserted in the shank of the drill. If the holes had been deeper, this method would not have been possible.

(b) The engraving of flat surfaces by an engraved roll on a horizontal miller. The roll revolves on the arbor, independent of the arbor, but is located lengthwise on it and controlled by a gear secured to the roll and engaging a rack on the milling machine table. The work to be engraved is correctly positioned on the table and the table feed engaged. By this means, the part to be engraved is oscillated slowly under the roll until the engraving is to the correct depth and clarity.

Work Handling

This phase of economic production has been very much in the forefront, and its significance is appreciated when we are told that its cost represents 80% of the total labour charges for an average shop. This seems a very high percentage, but one can realise that the more efficient the tooling becomes, the lower the ratio of tooling time to handling time.

The placing of batched work on pallets or stillages; the transfer of work from pallet to worktable and from worktable to pallet is a work handling method we can ill afford not to consider. Furthermore, if the pallet height can be arranged at table level, the operator will require less fatigue allowance on his so-called floor-to-floor time. Transport of loaded pallets can be by mechanical or hand hydraulic truck. If a fork lift truck can be afforded, work in transit from machine to machine can be stored vertically, with its resulting economy in floor space. It is generally agreed that machine operators who can be fully occupied in machining should not move pallets from location to location, but only labourers on instructions from movement control. Nevertheless, it is surprising how often machine utilisation is adversely affected in this way.

Machine Shop Labour as against Erection Shop Labour

The labour costs on an engineering product are the result of the time involved in machining and erection. Once the limits of inaccuracy and finish have been determined, the tolerances in machining are fixed so that the combined efforts in machine and erection shops give the minimum cost of producing that product. It is no use reducing the limits of inaccuracy in the machine shop for erection shop purposes, if the extra cost involved is not met by a corresponding reduction of erection costs. The intention of producing interchangeable product motions and detail parts is frequently obtained at unnecessarily high cost, whereas interchangeability, coupled with a little extra fitting, would meet the need at a reduced cost.

Zest in our Work

This is essential in achieving any measure of success, and foremen (who are actually part of management) should be imbued with this quality. The aim of the management is to put over to the workman, through the foreman, the principles underlying all decisions, which should be understood by the foremen and workmen. The policy of the firm is to provide the customer with reliable goods at a competitive price and, in doing so, the management and workpeople should be able to earn a reasonable return for their services. The workman likes to see plenty of materials ahead of him, whether as raw stock, work in progress, finished parts stores or completed machines to paint or pack. Only under such circumstances can the zeal we require operate through the workman in an endeavour to cut costs. Bottlenecks preventing these conditions should be attacked with almost commando tactics by the management.

Human Relationships within an Organisation

I have stated in a previous Paper that I consider this aspect of the firm's policy every bit as important as the technical ones. Willing co-operation by the workpeople, devoid of restrictive practices, is the goal, but it is almost impossible to get 100% co-operation. Nevertheless, I do not see that we have any alternative but to work in this direction and, as the workpeople gain more confidence in the management, hesitation and restriction will gradually disappear.

Reduction in production costs can mean some increase in earning power to the workpeople and profit to the firm and, as far as possible, should benefit the customer, workman and employer.

It is the management's duty to be on the alert to avoid clash of personalities within the organisation, and no man in the firm should be responsible to more than one person.

Encouragement should be given to anyone in the firm to voice reasonable grievances, since anyone working under a grievance is not in a position to give of his best.

PART II

SHELL MOULDING

by L. RIGG, M.I.Prod.E.

Mr. Rigg, who is Works Manager of Turner Tanning Machinery Co. Ltd., Bramley, Leeds, received his early training in the works and drawing office of the then L.N.E. Railway works at Doncaster.

He was appointed Assistant to the Chief Mechanical Engineer of the Bikaner State Railway, India, in 1925, subsequently becoming Works Manager and Chief Mechanical Engineer. In 1943, he was appointed Chief Mechanical Engineer of the Jodhpur Railway, which post he held until 1948, when India became independent.

On his return to the United Kingdom, Mr. Rigg took up his present appointment. He is a member of the Yorkshire Section Committee.

Mr. L. Rigg

NUMEROUS articles on shell moulding have appeared in the technical press during the past few months, but there has been surprisingly little factual information from firms employing the process. Such little information as is available, apart from the press, comes from second-hand sources. The pioneer firm in the field in this country has taken out patents covering certain aspects of the process and, as the patent position is somewhat obscure, this may account for the apparent reluctance to publicise results. I may add that for the same reason the firm with which I am connected is making practical investigations into the possibilities of the process only and is not in production.

Shell moulding is in its infancy in this country but it is making great strides towards more universal adoption. Rolls Royce and the Ford Motor Company, it is understood, are employing it extensively and the number of firms experimenting and developing runs into hundreds. There has been far more progress in the U.S.A. where a number of firms have set up elaborate plants for quantity production, and the annual consumption of the resin used in the sand mix is over 1,000 tons. The Ford Motor Company alone is casting about 150 tons of shell moulds per day.

The interest for the Production Engineer is in the vastly improved surface finish of the castings produced and the much closer limits which can be maintained.

Conventional Methods

The two well-known conventional methods of producing moulds are sand casting and die casting, but both have their limitations. Sand castings can be of almost any material and they are reasonably cheap to produce, but their dimensional limits are very wide. Die castings, on the other hand, are produced to close limits but are confined, in the main, to the light alloys and plastics.

There is also the lost wax or investment process, which produces castings to close limits in steel and other metals but is limited in its application, owing to the complexity of the process and the very high cost of the castings. Jet turbine blades cast in extremely hard alloys are examples of investment castings, and the high cost is more than justified in this instance by the reduced machining time possible with the close limits to which the blades are cast. Medical instruments of complicated shape cast in stainless steel are examples where costly castings, by reason of their precision, show to advantage over the forged article.

These three processes are restricted in use because of dimensional accuracy, limitation of material, or cost. Shell moulding, on the other hand, has none of these restrictions. The only limitation is the size of the casting. The heaviest so far produced is about 200 lb., but there is no reason to suppose that this is the ultimate size; methods of increasing it will undoubtedly be found. Shell moulds are being used for casting all metals except for some of the magnesium and lead alloys, and the type of mould and technique are the same for all. Jet turbine blades are now cast by the process in this country and in America; one motor company is casting 40,000 exhaust valves in steel and 4,000 to 5,000 crank shafts in special cast iron per eight-hour shift.

The Cost of Shell Casting

The cost of shell castings, generally speaking, is higher than for sand castings but not greatly so and there is no doubt that, with continued development,

Fig. 1

reduction will be possible. This pair of moulds (Figs. 1 and 2) for example, cost 2/3d. to produce, including labour and material. A pair of machine-made sand moulds for the same casting costs 1/11d. The time to produce two shells and clamp them together was 7½ minutes, the same as for sand moulds. The shells were not on a production basis, however, and I am sure that with simultaneous production from two or three patterns the time could be reduced to 5½ minutes and probably lower.

Machine moulding may reduce the time still further, but I would not like to commit myself on this point as information regarding shell moulding machines is somewhat scanty. They have reached the highest state of development in the U.S.A. where manually operated or completely automatic machines are available. It is doubtful whether they have reached perfection yet, although the makers of the latest machine claim a time cycle of 10 seconds per mould.

The material costs for shell moulds are appreciably higher than sand moulds, and with resin at 2/6d. per lb. it is essential to keep the percentage in the mix to a minimum. By using a coarser sand, at the expense of surface finish, the resin content can be reduced, and for light castings the thickness of the shell can be minimised. Even at the very minimum, however, the cost cannot compare with sand and, until resin prices fall, any reductions will have to be achieved by lower production times.

By far the most important advantage of shell moulding to the Production Engineer is in the close limits to which castings can be made, with consequent reduction in machining times. Two to three thousandths per inch of length is the generally accepted allowance, though I have seen castings to finer limits than these and also coarser. This casting produced from a similar mould to the sample is within .005″ of being truly circular and .003″ in

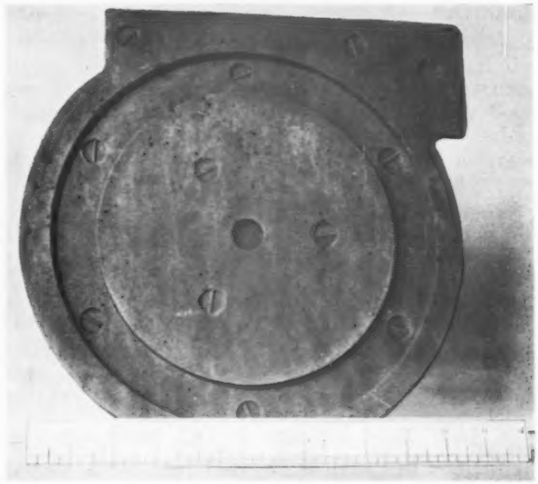


Fig. 2

width and parallel (Fig. 3). Incidentally, the latter dimension was the most difficult to maintain, owing to the tendency of the mould to distort at the joint line under the static pressure of the metal.

These wheels are machined to a .002″ limit on the diameter and with sand castings two separate turret lathe operations are necessary before the final grinding of the periphery. Shell castings require no turning operations; they are face ground on a magnetic chuck, jig drilled and reamed, and finally ground on the periphery as for sand castings. The modified machining operations show a saving of 20 minutes per wheel and, with reduced dressing of the casting, a saving of 3/9d. per wheel is possible in spite of the extra cost of the shell casting.

Time does not permit a comprehensive survey of the exploratory work done and, for brevity, I have quoted figures for one example only. Others have been examined, however, and show similar reductions in time and cost. Indeed, the more one looks into the matter, the more apparent does it become that this process can achieve worthwhile reductions in very many applications where quality of finish or accuracy

Fig. 3

are important. There are no guiding rules, however. It is not possible to say that shell moulding will reduce costs by such and such a percentage. Every case must be individually investigated on its own merits.

Advantage to the Foundry

From the foundry point of view the process has many advantages. Far less floor space is required for production. Moulds can be prepared in quantity and stored for future use; they are not affected by climate and are not easily damaged; moreover, being thin shells they occupy less space than their respective patterns.

The machining allowance of castings being minimised, the ratio of metal melted to finish casting weight is improved and, in most cases, reduced gate and runner sizes improve this ratio still further. Fettling costs are appreciably reduced.

Perhaps the most attractive aspect of shell moulding from the moulder's point of view is the absence of dirt. Indeed, some foundries clothe their shell moulding operatives in white coats. The moulding can be carried out in the cleanest shop without offence, and knock-out of castings is achieved with none of the inevitable dust clouds associated with this operation. Sand-handing is eliminated to a great extent with all its extensive handling equipment and floor space. Claims are also made that a more homogeneous metal is produced and that it is particularly suitable for pressure castings such as steam and gas fittings. On this point, I have not enough experience to comment. In our case, the castings produced have not differed greatly from any others.

The Shell Moulding Process

So much for the possibilities of the process. I conclude with a short description. Shell moulding was invented and patented in Germany in 1944 by one Johannes Cronin who, at the time, was investigating the possibilities of permanent sand moulds. It was found by the Occupying Forces and taken over by this country and the U.S.A., and is referred to in the Iron Foundry Productivity Team's Report as "the 'C' process". Basically, the process is the same as conventional moulding in that sand is packed around a pattern which is then withdrawn leaving an impression, into which molten metal is poured. The difference is in the sand which, in the case of shell moulding, is bonded with a phenolic resin instead of clay and is baked on to a heated pattern, followed by a period of curing in an oven.

The beauty of the process is in the great strength imparted to the sand by this resin bond; thus, moulds can be made much thinner and still resist deformation from the pressure of the metal. The thin wall further ensures the rapid egress of gases evolved at the mould face during casting and this, in turn, permits the use of much finer sand, with consequent superior casting finish.

Pure washed silica sand is used with the addition of from 4 to 8 per cent. of finely powdered phenolic resin, the amount depending upon the fineness of the sand and the weight of the casting. This type of fine sand is expensive but, as the cost is only a fraction of the total cost of the shell, it is worthwhile getting the best.

The mixture of sand and resin is held in a dump box mounted on trunnions and open at one end. The pattern is heated in an oven to approximately 450°F., sprayed with a parting compound and clamped to the open end of the dump box which is then inverted on its trunnions. The dump box is sufficiently large to ensure that, when inverted, the mixture falls at least 15″ on to the heated pattern. When the mixture is in contact with the hot pattern, the resin rapidly liquefies, disperses through the sand and re-solidifies. This operation is very quick; depending on the thick-

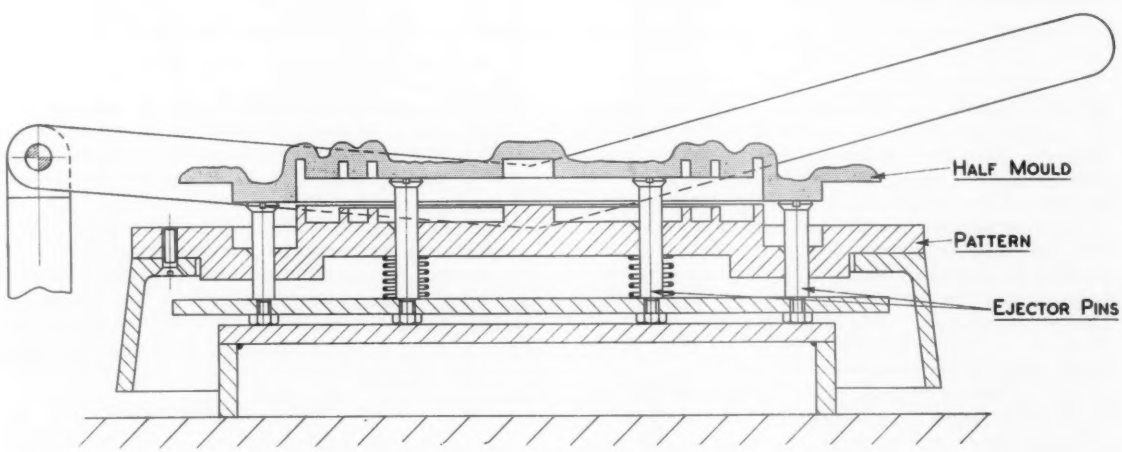


Fig. 4

ness of the shell required and the heat of the pattern, it takes from five to fifteen seconds. (The plain shell shown in Fig. 2 was done in five seconds; the other with the thin annular rings (Fig. 1) was given fifteen seconds to ensure sufficient resin being cured on to the thin sections.) After this investment period, the pattern is removed from the dump box with the shell adhering, and is replaced in the oven for a curing period of two minutes.

The shell is ejected from the pattern by spring loaded pins (Fig. 4). This can be the most difficult operation as, unless an efficient parting medium is used, the shell sticks to the pattern. So far, the most efficient medium found is a silicon compound in liquid form which is sprayed on to the hot pattern, one application usually being sufficient for six or seven shells.

The whole operation can be performed by unskilled labour, once the correct pattern equipment, mixing and heating facilities have been established.

Patterns made in fine grained cast iron give the best results; aluminium is more easily worked and far lighter to handle but does not retain the heat nearly so much or so evenly as cast iron. Moreover it is attacked by the ammonia given off during curing.

The thickness of the patterns is kept as uniform as possible to ensure equal surface heat and consequent uniform shell thickness. Pattern taper is very small; .003" was allowed on these pin wheels.

This talk has been necessarily short but I hope I have conveyed clearly some of the possibilities of the process. There is no doubt that it will, in the not-so-distant future, become a real aid to more economic production.

PART III

JIG COSTS—CAN THEY BE REDUCED?

by H. CROMPTON, M.I.Prod.E.

Mr. H. Crompton

Mr. Crompton, who is a Tool Consultant and Designer, served his apprenticeship with Davies & Metcalfe, Ltd., Stockport, and then joined Vickers-Armstrongs, Ltd., Crayford, as a Tool Designer.

After varied appointments with Ford Motor Company; Vauxhall Motors; Wm. Asquith, Ltd., and Blackburn Aircraft, he was appointed Chief of the Jig & Tool Department at John Fowlers (Leeds) Limited, where during the last War he controlled design and manufacture of jigs for tank and engine production.

Mr. Crompton is a member of the Yorkshire Section Committee.

I APOLOGISE for presuming to talk on such a subject to those to whom it is an everyday concern. However, it is a subject on which I feel very strongly and which I think should be in the front of all our minds.

Standing as I do, neither as a maker or a user of jigs, although I am intimately concerned with both, I may perhaps be permitted to say a few things which will help to put the problem of jig costs into a little clearer perspective. You may disagree with many things I say, but I hope my remarks will give you the opportunity to say what you think.

The following remarks are intended to apply to small shops working largely upon batch production.

To the owner or manager of a small shop, jigs have come to mean a costly but unfortunately necessary evil. He realises that without jigs of some sort he cannot attain economic production nor interchangeability, but for all that he very much begrudges the cost of tooling. In this, he is apparently justified because a feeling has grown up that jigs are necessarily expensive and that as soon as you begin jigging, you have to spend hundreds of pounds. This of course is not so. Jigs are not necessarily expensive and the expense can be minimised by appropriate action in various directions, summarised as follows:

1. By making only those jigs which are absolutely necessary.
2. By better, simpler, quicker jig design.
3. By exploiting any special facilities which may exist in the factory.

4. By the reduction of manufacturing costs.
5. By better buying.

Don't let any jig expert or planning engineer run away with the idea that no work at all can be done without jigs, e.g. very many first operations can be done in ordinary chuck jaws, or clamped to a planing machine table, etc.

I would include under this heading the provision of such things as marking out templates or sighting plates for use on the chucking lathe. These things can hardly be called jigs, but they can well obviate the necessity for a jig.

Jig Design

This is a thorny subject, the quality of a proposed jig too often lying in the opinion of the viewer, whether he be chief draughtsman, section leader or any other person who sees it on the drawing-board. All these people unfortunately seem to have pet ideas and if you are lucky enough to have an imaginative jig and tool designer, they can very soon cramp his style. What we want in the batch production shop is a rugged simplicity, simple clamping, easy cleaning, etc., and if we can get our jig designer to think on these lines, thrusting directly at the problem concerned instead of going all round it, we shall save considerable time.

We should stress to our designers the following points:—

(a) That toolmakers are not thought-readers—everything on the drawing should be clearly specified. Any obscurities lead to extra estimated costs to cover contingencies. Clarity on the tool drawing will obviate endless queries and visits to and from the toolroom—all time and cash consuming.

(b) Assembly drawings could well carry all important dimensions, so that various items could be lined up on assembly, thus obviating the necessity for some jig boring.

(c) Every piece of metal used should be capable of being cut from a standard bar; if the jigs are to be made in your own shop, then you can give the draughtsman a list of the material sizes to be found in your stores, but if the jigs are to be made outside, then commonsense will have to indicate what sizes are likely to be available, for instance, 2″ by 1″ and 3″ by $\frac{1}{2}$″ may be found in a jig-maker's store, but it is extremely unlikely that he will have 7″ by $\frac{1}{2}$″ or 5″ by $2\frac{1}{2}$″. Usually it does not matter if a jig part is $4\frac{7}{8}$″ wide instead of 5″, or $\frac{7}{8}$″ thick instead of 1″, but if these seemingly odd sizes are used, just under even figures, then a minimum of time will be spent in the toolroom carving away surplus material. This is a very elementary point, but I suggest that up to 75% of the drawings produced seem to ignore it. Have a look at some of your own drawings to see if this is not so—perhaps in your case the toolmaker uses adequate discretion.

(d) Where castings are used in jig construction they should, wherever possible, be capable of being moulded simply by a straight draw without loose pieces or core-boxes, although of course they must sometimes be used. Always, however, they should be kept to a minimum. I have seen a jig, quite a small one, which called for 26 loose pieces, if the jig was to be made as the designer drew it. This is absurd and if the tool designer does not know anything about foundry practice, send him down into the foundry for a week or longer.

(e) Standard jig parts are available today to quite a considerable extent, although not nearly as widely as would be an advantage. Given the right attitude in the Design Office, considerable saving can be effected by their use. On the face of it they seem to be dear to buy, but they are cheaper than the corresponding articles made singly in your own shop, especially when you take into account all the extra time which is overlooked, for instance, draughtsman's time, drawing the part out, cutting off in the steel stores, etc. It is my belief that many other articles would lend themselves to standardisation, e.g. clamps are available in a very restricted range at present; they could be much more varied.

(f) A very good way of saving jig cost at the design stage is to adopt standard jigs for similar parts. These can take the form of, firstly, adjustable jigs to cover a range of components, e.g. a jig to drill the bolt holes in oval flanges; secondly, jigs with interchangeable location pieces for a range of similar parts, or thirdly, they can be jigs of a standard design for similar components. Examples are the Cone Lok Jig made in America by Woodworth & Co., Detroit, which is a drill jig consisting of a base with a top drill plate pulled down on two pillars by means of a self-locking mechanism in the base; and an aircraft firm who, continually faced with the problem of drilling the cross-hole in the ends of sockets, have adopted the procedure of stocking standard jig castings which are kept in the stores ready to be bored and milled to suit the various components as they come along. This procedure in their case, saves a lot of time, firstly in the Design Office and secondly in the jig manufacture.

(g) A very important item—give much thought to the jig maker's tolerances. These should be as wide as you can make them. Never put decimal dimensions without limits if most of your dimensions are in fractions, and keep your limited dimensions to a minimum number.

Using Your Factory Facilities

Many factories are particularly well equipped in one direction or another, which can be turned to account when we are reducing jig costs.

You may well be able to provide your own jig castings. You may be well placed for the speedy

manufacture of welded assemblies, in which case use them for jig bodies and brackets; or you may have a first-class grinding section which can relieve the toolroom of the straightforward job; or a horizontal borer not fully occupied which can relieve the jig borer.

Reduction of Jig Making Costs

The biggest question in jig making is jig boring and we have let this become a real bottleneck and expense. This, I think, is because we have come to regard the jig boring machine like a precision measuring instrument, rather than as a machine tool fit for hard and continuous work. We have carefully chosen our operators as those men most likely to nurse and least likely to damage their machines. We have given them white coats and glass houses. Nowadays they do not pick up a drill without washing their hands, or put a jig on the table without getting the vacuum cleaner out. This is wrong—they should be required to work their machines to capacity, to drill from solid instead of having holes roughed out elsewhere; to centre drill, drill and ream or endmill wherever practical, cutting out much single point boring to plug gauges. Many jigs could be taken off the jig borer after centre drilling and the holes finished on a radial drill. Treat the jig borer as a high class drilling machine—wear it out with honest work and then get it reconditioned. The cost of machine and service will be recovered many times over.

The makers will guarantee the machine to $\pm .0001''$ or $\pm .0002''$ and this can be achieved with very great care on the part of the operators. If we can give him $\pm .001''$ or as much as $\pm .005''$ he can, if he wishes, rattle along at twice the speed, or even more.

This question of limits has a very direct bearing on jig costs when quotations are requested from toolmakers, as also has the dimensional system adopted. They will always quote lower for wide limits. Square centres should always be quoted—even if a circular table is nominally available, it is often in use elsewhere, or is too heavy to lift up for one odd jig and if you assume that angular dimensions are correct, the jig borer operator often will stop to work out the square centres for himself—on a bit of paper which is promptly lost! Any inspection of centres will usually be done away from the circular table and square centres are required once more. (But consult the layout of the machine before selecting the datum lines for your ordinates.) Why the Design Office cannot dimension in this manner in the first place, I do not know.

Another way to reduce manufacturing costs is to avoid unnecessary fine finish on the various subsidiary parts of a jig. This is a bogey which is difficult to lay—it is part of the jig complex. The toolmaker—the boss, I mean—or the tool room foreman will say that the cultivation of a good all-round finish engenders pride of work, tidiness of mind, and the habit of care in the toolmaker, but it leads to more undesirable things than this as we all know. And the salesmanship angle to it, i.e. the " you can tell it is one of ours " idea, can overreach itself, especially with Yorkshiremen or other discerning people.

Need for More Toolmakers

Are you as employers doing your share in keeping up and enlarging the number of toolmakers? Outside prices are high largely through lack of competition and we only place orders outside because we have not enough toolmakers of our own (with the necessary plant and space). A good general fitter can be used to excellent effect in a toolroom where the work is intelligently given out, and I would as soon see young fitters brought into the toolroom after production experience as see boys completely trained there.

Also, many jobs done in the average toolroom can be done equally well in a production shop. I know that in a " big production " shop this is most inconvenient, but in the medium or smaller " batch prod. " shop it is quite easy to arrange.

If you want to get tool costs down, increase your toolroom jig output by refraining from using the toolroom as an experimental or repair shop, e.g. if there is an awkward grinding operation on a component, see that the production shop acquires the necessary tackle to do the job and release the toolroom machine (and man) for their proper job.

Better Buying

Why cannot customer and toolmaker get together to establish a standard for the class of work wanted? Is competitive quotation the cheapest way of buying jigs? Why the enormous difference in quotation for any one jig, say £90 against £40 ?

The answer lies mainly in presence or absence of a suitable machine for some essential part of that jig—possibly what could be planed has to be milled, or handling facilities are lacking, etc., therefore place your enquiry or order with an intimate knowledge of the plant available. Allow one of your technical staff to handle the enquiries and give him facilities to seek out suitable toolmakers.

Do not be too exacting with jig inspection if price has been a large factor in deciding where the order is to be placed. I suggest that the inspection of " first off " is quite adequate in most cases.

It is my strong belief that for a firm placing regular work outside there is more money to be saved by intelligent buying than at any other stage (except, possibly, in cost accounting, which is another story).

DISCUSSION

Chairman: Mr. F. T. NURRISH, M.B.E., M.I.Prod.E.

Before opening the meeting for discussion, the Chairman said he would like to make a few remarks regarding Mr. Crompton's very interesting contribution. He continued:

"Mr. Crompton talked about jig boring to limits of .005". I suggest you do not use a jig borer for limits of this order. Jig borers are precision tools and tolerances of ± .005" are regarded as very coarse tolerances these days. He mentioned the cost of inspection; I maintain that inspection must be regarded as an aid and not a hindrance to production. I suggest that a lot of time could be saved if inspection was carried out in a proper sequence. It is not very nice for a toolmaker to produce tools to limits of ± .0001", and then when he takes it along to inspection, the inspector says it is .0002" out. Inspection of all accurate parts of jigs, tools, etc., should be carried out by the inspector with the operator, before removal from the machine where possible.

"Mr. Crompton also mentioned that employers were not doing their fair share regarding improving conditions for their tool room personnel, and providing them with the necessary tackle, etc. The majority of employers, I would suggest, *are* doing their fair share. In all well-organised establishments money is being spent constantly on up-to-date plant and equipment, as this becomes available. This is essential in these days, as the old type of craftsman toolmakers are becoming more and more non-existent, and therefore we have to make machines do what the craftsman did in the past.

"With regard to Mr. Rigg's very interesting talk on shell-moulding to produce accurate castings, many years ago Lord Austin, who was a late President of this Institution, made a plea for study to be given to providing castings with less machining allowances, with a resultant saving in raw material and labour for the automobile trade. I am very glad indeed to see the developments which Mr. Rigg has described and shown samples of tonight.

"Referring to Mr. Turnbull's remarks, I think he made some comments regarding the economic use of materials we have available. It has always grieved me that, in this country, the material suppliers do not work as closely with the users of the material as they should do, and this is a very important matter. They are working much more closely in the U.S.A. than here, as I know they did in Germany before the War."

During the Discussion the following points were raised:—

Mr. Horn asked for more information on the method adopted in shell moulding.

Mr. Rigg explained that the metal pattern was mounted on a frame, the pattern being made to precise limits. Underneath was a spring plate and pins were used for ejecting. The mould was then heated to 480/500°F. and then placed over a dump box which was mounted on a trunnion.

This was turned over and the sand covered it to the thickness required. It was then brought back to the vertical and put in the oven and baked for two minutes.

(Mr. Rigg gave a demonstration with a pattern.)

Mr. Nurrish asked if it would pay to apply direct heat to the moulding plates to save taking to the oven.

Mr. Rigg replied that experiments with electric heating directly to the plates were being carried out.

In reply to Mr. Turnbull, Mr. Rigg said that the mould could not be reclaimed.

Mr. David asked for some idea of the minimum economic batch quantity where shell moulding would pay.

Mr. Rigg said this was a difficult question. If it was a simple article, it might pay to make a pattern for it. The deciding factor was what was going to be paid on the subsequent machining, and in consequence every case had to be decided on its own merits.

Mr. Johnson asked if the shell method of moulding would be more or as economical as the plate moulding for that type of component in quantity.

Mr. Rigg replied that it would for this wheel which had to be turned up to fine limits; therefore the machining had to be done carefully. When shell moulded, it was ground on the periphery and there was a saving of 3/9d. per wheel in machining.

Mr. Brooks asked if the moulds were particularly sensitive to ramming density, or did they form under gravity.

Mr. Rigg said it was essential to get the loose sand as high as possible, so that the sand could fall at least 12/15 ins. on to the pattern. Some boxes had doors and the sand fell automatically.

Mr. Keighley, referring to the emphasis on limits, said he found that limits could be taken from B.S. or Newall's tables, which were found to be far too close. It seemed that the whole system of limits required reviewing. The Production Engineer seemed to think that the draughtsman's aim in life was to make things as difficult as possible to produce.

Mr. Turnbull replied that as he had been a draughtsman for many years, and had found that experience very helpful in his subsequent work, he appreciated Mr. Keighley's criticisms, but a knowledge of practical circumstances enabled one to make practical decisions and the book of Newall limits did not enable one to help the Works to the maximum ability. He appreciated that it might be rather dis-

heartening but he thought that it would explain itself when Mr. Keighley had some works experience to couple with his draughtsmanship.

MR. CROMPTON said that his point was that the wider the limits, the cheaper production was likely to be. It was not all the fault of the design office, as he had seen drawings from the design office where there were quite wide tolerances on centres. But the draughtsman was inclined to say that much finer tolerances could be worked to with a jig borer, and that was the sort of thing he would like to see cut out. The jig borer should be given as wide a limit as possible and surely then it would come into the wider limit.

MR. HOYLE stated that after listening to Mr. Crompton's and Mr. Turnbull's remarks about tolerances on drawings, he would like to make a few remarks regarding the co-operation of the inspection department, which should be a lot more flexible than was generally the case. What the designer wanted was on the drawing—if he wanted .0005″ limit, he should get it and the Inspector should see that it was there.

MR. TURNBULL replied that he appreciated this point. He thought it was more a matter of team work than individual points of view, and in taking all aspects into consideration in the Works a point could be arrived at which was the basis for mass production, and a full knowledge of manufacturing requirements was the only deciding factor of what it should be.

(*continued on page* 587)

MECHANICAL AIDS TO PRODUCTION

by J. E. STEEL, M.I.Prod.E.

Managing Director, Steels Engineering Products, Ltd., Sunderland.

An abridged version of the Paper presented to the North Eastern Section of the Institution, on 17th November, 1952.

THE title of this Paper refers to the provision of mechanical aids to the processes and operations which themselves might be regarded as being incidental to production, but nevertheless are essential to it. By this is meant all the movements and handling of material in connection with the production processes, and the consideration of the provision of mechanical aids to improve the efficiency of these incidental operations, but not the mechanisation of the actual production processes themselves.

Measuring the Problem

The costs of material movement and handling vary very widely between industries and products. Careful investigation has disclosed that the cost of this handling will vary as widely as from 10% of the finished product cost to 80% of the finished product cost. The low figure applies to those products in which the material value is small, the material itself light and of reasonable and easy unit weight, and the conversion labour relatively high.

In such a type of production, the total costs of materials movement and handling cannot loom large against the final product cost, and there is probably not very much to be gained by the provision of mechanical aids. Even so, it will be found that a reconsideration of the handling problems will almost inevitably show up unnecessary movements, double handling, undesirably small batches, and so on, with indications for potential economies.

At the other end of the scale there is the type of product which has practically no conversion labour applied to it at all, and in which the final product cost is very largely composed of material and the cost of moving it. A typical example is the coal industry where the material value itself must be regarded as low, since it is probably covered by the 6d. per ton paid out originally in royalties and subsequently bought out on this basis by the Government, so that every phase of handling and movement from hacking or blasting the coal out of the face until it is finally delivered to the user is adding to its costs, and is indeed the only permissible addition to the original price of 6d., apart from a very small charge which might be regarded as processing insofar as the material may be cleaned or graded. In other heavy industries, the material content is higher in value, but again the true conversion labour is relatively low and almost the whole of the added cost is in handling in one form or another.

The average type of engineering production generally falls somewhere between these two limits. A typical engineering product in the North East of England would have its final product cost made up as follows : 50% material, 17% direct conversion labour, and 33% total on cost. Of this latter perhaps $33\frac{1}{3}$%, representing say 11% of the final product cost, will probably be found to be concerned with the movement and handling of the material, whether raw material, part-finished, bought-in components, or finished product in some form or other.

In most production jobs, careful analysis will reveal that many tons of material have been moved to produce one ton of finshed product at the end. In one reasonably well laid-out and modern engineering factory, the history of one casting weighing approximately 1 cwt. was traced, and it was found that, from the foundry floor to the finished product going out of

the gates, the casting was handled no less than 62 times. Approximately twenty of these were required each week, so that to incorporate one ton of this casting in the finished product each week involved the handling and movement of no less than 62 tons.

A number of these moves is inevitable, as the casting must come from the foundry to the engineering factory, and must be handled in and out of a number of different machines, and the quantity is too small to warrant any elaborate continuous handling process equipment. But it is significant that improved methods dealing, of course, with many other parts besides this particular casting quoted as an example, cut down the number of times the casting was handled from 62 to 30 and thereby saved the cost of moving no less than 32 tons per week, or 1,600 tons per annum.

To get some true measure of the cost of material movement and handling, each of us should, in the plants for which we are responsible, consider very carefully what is spent on this work, and how much this totals of the overall cost of the product, to see how large a problem has to be faced in each factory, and consequently how worthy it may be of attention. It must be remembered that the cost of such work is not just the sum of those workpeople who are clearly charged to labouring or transport or materials handling, or whatever costing sub-heading is given to it. Everything must be taken into consideration, including the cost of shop labourers, which tends to get submerged in some general shop overhead; the amount of time allowances given to machinists because they have a certain amount of this handling to do themselves; the amount of time allowances which could be saved if proper local handling equipment were provided to enable them to load and unload their machines more rapidly; the cost of idle time or waiting time because of the inadequacy of the main lifting equipment in the department.

To this must be added the cost, maintenance and depreciation of any existing equipment for lifting and handling. Better methods giving an improved utilisation of space would show how large a capital cost in space and buildings alone must possibly be added in the computation.

Greatest Scope for Economy

Probably the greatest scope today for economy in production lies in this problem of materials handling and movement, as it is—and quite naturally—the "Cinderella" department of any business, except those in which by their nature it looms so large as to have necessitated the right sort of thought and application long ago.

For example, in any typical engineering works the technical management is bound to be very much more interested in better and more efficient ways of carrying out technical processes than in the comparatively simple process of moving material. As a result, the location and arrangement of stockyard and stores, the methods of handling in and out of stockyard, transporting to workshop, handling between processes, the size of batches, the units in which the material is moved, and so on, are accepted as facts and never investigated.

The expert in materials handling is taught how to analyse the problem, and brings a properly trained enquiring mind to bear on *why* a thing is done in such-and-such a way, or material is kept in such-and-such a place. Those responsible for production in any plant could probably do it themselves, provided that they take the time away from their other production interests and activities to do it properly, and really divorce themselves from tradition and usage in the plant, considering every aspect of the problem with an open mind. It is well to emphasise this, because new phases of engineering activity, such as materials handling, tend to create around them an air of mystery, which results in their being viewed with suspicion.

Like all other problems, this is a matter very largely of commonsense, and we must not feel that it is something extremely complex and expensive, and only for the few. It is genuinely a matter which everyone should consider, as most substantial savings are possible.

Handling Charges and Product Cost

It is also helpful to consider what has been done in those industries where the handling charges represent the major part of the product cost, or at least a substantial proportion of it, and so to realise that what has been done in the provision of mechanical aids in these industries is now accepted as a matter of absolutely standard practice, and that the reasons which prompted those in charge of these industries to take such steps are exactly the same reasons as should prompt all of us to investigate this problem more closely.

Obvious examples can be found in coal and grain handling, where vast quantities of materials of uniform size and consistency lend themselves to something better than the old hand methods, and where the proportion of the cost of handling to the total cost makes improved methods a necessity. The time has now come to continue this process of investigation into handling costs, into the smaller and more intricate problems involved in a general engineering works or production of that kind.

There have been numerous examples of extremely intricate and, incidentally, costly mechanical handling installations in ordinary engineering works, where the size of the operation and total volume of the work handled warrant the cost and complexity of the installation. It will be appreciated that in a large motor-car factory it would be virtually impossible today to handle the very considerable mass of material, and at the same time to implement the production-planning system, without the complicated conveyor installations which make the whole thing work, save a vast army of handling labour, and at the same time economise on space which would otherwise be taken up by work-in-progress, etc.

It should be noted, too, that in the various A.A.C.P. Productivity Reports which have been issued by a wide variety of industries which sent Teams to the United States, almost without exception one of the main items raised is the vastly improved materials handling methods and systems employed, and the much greater efficiency in American industry in this respect compared with our own. This is of particular interest since it must be remembered that the teams consisted of experts in their own particular lines and processes, who were not materials handling engineers. More important still, however, is to note the comments made that the Americans have not any newer or better or different equipment than is available in this country in general, but that they *use* it.

A Fresh Approach

The first essential is to become conscious of the size and nature of the problem. We must then scrap all preconceived ideas as to present methods of doing things, and consider the ideal set-up for each particular job, bearing in mind the most favourable location of the materials, arrangement of works and shops, ideal batch sizes, and so on. We must work to the established principles of sound materials handling; of obtaining as direct a flow as possible; selecting the optimum unit load and maintaining it strictly, throughout the various necessary movements; using the best available mechanical means so as to handle a larger unit load, and take the "hand work" out of it; letting the machine do the job rather than the man, and organising both the location of the work and the routing of the materials so that the mechanical aids (or mechanical transport) have the minimum of light load running; and considering the ideal means of handling the individual pieces when the pre-established unit load has to be broken down at various process operations. All this should first be done on the absolutely ideal basis, realising that physical limitations of site, existing buildings and so on may modify the scheme.

It will certainly often be found that there are substantial savings to be made without provision of a single piece of mechanical equipment, simply by taking the time to study what is being done, asking why, and considering whether it cannot be better arranged or better controlled.

By revising the batch sizes, increasing the unit load, handling the unit load throughout as far as possible, further considerable savings can be made, although these will involve a certain amount of comparatively simple equipment, such as stillages or pallets, and the means of transporting them. Investigation may show that a more extensive re-arrangement of the premises, stores and so on will make further savings, but of course these must be measured against the increased cost.

The saving to be effected by the installation of suitable mechanical aids is often measured by the actual cost of the labour so replaced, and it is emphasised that in this consideration must be included not only the obvious labouring help, but also the proportion of the process workers' time which would also be saved. In addition must be considered the increased speed of operations, the saving of space, and the better flow and control which improved handling methods give.

In studying optimum handling methods, it must be recognised that the type of equipment required is greatly affected by the components of frequency and distance in the formula compounded of volume x frequency x distance, and if the distance is small there is a lesser case for powered equipment for travel. Where the distance is greater, powered travel is essential. But where the distance is greater still, then it is wrong to use the same equipment for travel as for handling.

Thus, in a confined space a wheeled stillage is easily moved by man power to its next station. With a greater distance a powered stillage truck will increase efficiency; but with a greater distance still, it is wasteful to use for transport only over a large proportion of its time a machine which has lifting and handling facilities and which are reflected in its capital cost.

For example, it may be decided to use pallets for the components to be handled, deciding first their ideal size to carry the predetermined unit load. It may well be found that a fork truck is necessary to handle these, including handling them to a considerable height in stores, etc. If the total volume is not too great and the distance between moves is small, the fork truck will also do the transporting. But if the distances to be travelled are considerable, it would be very wasteful to use this comparatively expensive and complex lifting and handling machine for a job of pure transportation. This would lend itself perhaps to a combination of lift trucks and tractor and trailers. Thus the fork or lift trucks would operate—with a full-time utilisation—one at each end of the line, and the intervening journey would be handled, again more efficiently in terms of both labour and capital cost, by a tractor and trailer train.

The Question of Volume

Apart from the problems of frequency and distance, the question of volume alone introduces some interesting calculations affecting the ideal set-up and minimum capital outlay. Thus, if it is assumed that a particular problem is best dealt with by a simple standardised stillage, it will be found that if the volume is low and the total number of stillages is consequently small, it will be cheapest in capital cost, and satisfactorily efficient in operation, to have these each with four wheels, each capable of being moved on its own. If the number has to be greater than this minimum, then it is cheaper in capital cost, and still equally efficient in operation, to use stillages with only two wheels each and provide the "tug-lift" type of accessory, one of which will handle very many stillages, and the saving of two wheels and an axle on every stillage will pay many times over for the cost of the "tug-lift". But if the number of stillages is greater still, then it is cheaper

to have these with no wheels and use the more expensive type of moving accessory which will lift and transport the "dead" stillage.

No hard and fast rules can be laid down, as so many factors must be taken into consideration. It is because of the complexities introduced by distance, layout, ground surface, gradients, storage facilities and so on, that the services of an expert skilled in making a materials handling survey and report will produce the best answer.

If the Production Engineer has a clear, "cut and dried" problem, constant in volume and size of component, and with a definite and unchanging process layout, he should have no difficulty in arriving at a proper solution to the handling requirements. There may be more than one way of doing the job, and cases will be made out by the protagonists of differing systems or equipment, but the choice should not be difficult.

But in the much more diverse and variable problems facing the Production Engineer of the average engineering works, this will not apply, and it is essential to have a handling system and appropriate equipment which is as flexible as possible, and which is capable of dealing with as wide a field as possible of the lifting and handling problems involved, and with the mobility necessary to cater for variations in products and components and layout from time to time. Here again the incidental but tremendous indirect capital savings made in the better utilisation of space and buildings must be emphasised.

Other Mechanical Aids

In the foregoing the mechanical handling and movement of materials and components have been considered, but under the generic heading of the Paper it is right to make reference to other mechanical aids to production, such as isolated lifting equipment, special manipulators and so on. These, being much more closely and intimately connected with the ordinary production processes, probably do already get much more attention from the Production Engineer, but it is most noticeable, again in the United States, how much more this type of ancillary equipment is used, some of it only "faked up" in the roughest manner, but providing some additional mechanical aid to the operator. For example, the Americans will make some simple purpose-made manipulator for the welding of a component and feel it well worth while to make both this and a jig for a quantity of, say, only 25 off. We tend to feel that the cost of any such special equipment is wasted unless it is spread over a very large quantity, and so frequently leave the operator wrestling with the component under very adverse conditions. The Americans are, perhaps, a little more fortunate than we in being able to obtain quantity-produced simple equipment for building into jigs, manipulators, hydraulic or pneumatic lift gadgets, and so on, but the provision of these is only just following the demand, which can easily be created in this country.

It is, for example, noticeable, in the States, how much more easily plates are handled in any cutting or shaping operation, by using a simple and cheap arrangement in which a gadget consisting of a large spring-loaded ball, held in a cup at the base of which is a gas thread, and so arranged that with a few of these screwed on to a stand or plate or table, the piece of plate superimposed on them can be swung round, pushed forward, or pulled from one side to the other with the greatest of ease by one man. Little things like this, like the spring balances they have on all their hand tools such as drills, nut-runners, special individual lifting gear, hydraulically or pneumatically-operated lift tables, and so on, all ease the work and speed it up. There is practically nothing in the foregoing items which cannot be seen in this country, but the difference is that in the States it is seen everywhere, here only occasionally.

A man should never do the hard way what he can do more easily by using the mechanical aids with which we are equipped in this present age, and the purpose of this Paper is to emphasise the need for investigating materials handling and movement problems, and of applying mechanical aids to give an improved efficiency.

SYMPOSIUM — DISCUSSION

(continued from page 584)

Mr. Kenyon said that Mr. Rigg had touched on a subject of which little was known and he was glad that Mr. Rigg spoke so highly of shell moulding, because one of the difficulties in the foundry was getting the joint line correct. If shell moulding was going to ensure a good parting line and a good register, then it should be adopted right away. With regard to cheapening the cost of jigs, Mr. Crompton had mentioned welded jigs. In about thirty years' experience, Mr. Kenyon had become a firm antagonist of welded jigs or fixtures. Cast jigs by their very nature were more stable. They absorbed vibration to a greater extent and retained their accuracy. Fabricated jigs did not maintain the same accuracy and had not the same stability.

Mr. Crompton replied that he had only brought in the question of cast or welded jigs on the score of cheapness. If a Works was well equipped to flame cut quickly—there was so much difference in the time—it would pay to use more welded assemblies in preference to jigs made from cast iron if the Works did not have its own foundry and pattern shop. As regards which was the best, he was wholeheartedly for the castings if expense and time did not matter. One of the whole points of his Paper was that unnecessary accuracy was being sought. Many jigs were bases only and he did not agree that the cast was better than the welded assembly. He knew one or two firms who never used a casting in their jigs. If the welded assembly was normalised and as many stresses as possible relieved, this was a close approach to the casting.

REPORT OF THE MEETING OF COUNCIL

Thursday, 29th October, 1953.

THE second Council Meeting of the 1953/54 Session took place at 36, Portman Square, London, W.1, on Thursday, 29th October, 1953.

Mr. G. R. Pryor, Vice-Chairman of Council, presided over the Meeting until the arrival of the Chairman, Mr. H. Burke, who had been delayed by fog. Twenty-eight members were present at the Meeting, together with Mr. W. G. Key, Chairman of the Wolverhampton Graduate Section, and Mr. R. J. Read, Chairman of the Birmingham Graduate Section.

Finance

The Institution's Accounts for the twelve months ended 30th June, 1953, were presented. The gross surplus at the end of the year was not as large as had been anticipated, which was almost entirely due to increased Section expenditure. This matter was discussed at some length and it was generally felt that economies could be effected by more careful planning. Council agreed that the F. & G.P. Committee should be asked to study the matter carefully and make recommendations to the next Council Meeting.

New Building Fund

The Vice-Chairman reported that contributions to the New Building Fund now amount to £7,674. A small sub-committee had been appointed to deal with alterations and decorations. It was hoped that the Institution would move into the new premises early next year. (Following the luncheon adjournment, Council Members visited the new premises at 10, Chesterfield Street, W.1.)

British Productivity Council

A number of Section representatives reported on progress in their respective areas regarding the formation of local Productivity Committees.

The President felt that although the main efforts of members must naturally be devoted to furthering the interests of the Institution, co-operation with the British Productivity Council was important. It was agreed that the Research Committee should be asked to draw up a document which, after approval by Council, could be issued for guidance on this subject.

Dr. H. Schofield, C.B.E.

Council unanimously approved a recommendation from the F. & G.P. Committee that Dr. H. Schofield, C.B.E., be elected an Honorary Member of the Institution, in recognition of his long and valuable service to the Profession.

International Conference, 1954

The F. & G.P. Committee reported that a Special Committee, under the Chairmanship of Mr. M. Seaman, had now been formed to deal with the organisation of an International Production Conference, to be held at Olympia in July, 1954, and to give advice and guidance on the Exhibition which is to run concurrently with the Conference.

Liaison with Overseas Sections

Council agreed that there should be a permanent item on the Council Agenda which would give the Vice-Chairman of Council the opportunity to report on any matters arising from his duties in connection with liaison with Sections outside the United Kingdom.

Section Hon. Secretaries

A resolution put to Council by Mr. H. W. Bowen, that a provision be inserted in the Articles of Association to the effect that the Council can appoint a Section Hon. Secretary who is not a member of the Institution, and that whether qualified for membership or not, such person may serve as Section Hon. Secretary for the period for which he or she is nominated, was unanimously carried.

Doncaster Sub-Section

Council approved the formation of a Sub-Section in Doncaster, under the guidance of the Sheffield Section.

Education

The Education Committee had collaborated with the Institute of Personnel Management in providing a short course on Work Study for Personnel Managers, to be held at the College of Aeronautics, Cranfield, in November.

Lord Austin Prize, 1952

The Lord Austin Prize for the best essay by a Graduate in 1952 would be awarded to Mr. V. C. Jones for his essay on "The Pressure Die Casting Process (with special reference to light alloy casting)".

Journal

It was reported by the Editorial Committee that the economic position of the Journal remained satisfactory, and the revenue from advertising was steadily increasing. The Committee were giving thought to the possibility of publishing in the Journal a number of technical Papers by leading American authorities.

The Papers Committee had met with an encouraging response to their appeal to Sections to concentrate on submitting for consideration at least one first-class Paper each Session.

Research

The Research Committee had been invited by D.S.I.R. to collaborate in a research project put forward by the University of Edinburgh concerning "The Operation of Quality Control in Industry". The Committee had agreed to assist in any way possible and had already had a meeting with Mr. McKenzie of the Department of Psychology, Edinburgh University.

Materials Handling

The "Review of Materials Handling in British Manufacturing Industries" had now been published, and had received favourable notice. Orders had been received for over 1,200 copies to date.

Materials Utilisation

The Sub-Committee dealing with the investigation had sought the assistance of Sections in obtaining Case Studies, and meetings had been arranged with representatives of the Ministry of Supply Metals Economy Advisory Committee, and of the British Productivity Council.

Members of the Committee had also visited Sections, at their request, to advise on the setting up of Working Groups.

Measurement of Productivity

The work of the Sub-Committees of the Joint Committee on Measurement of Productivity, dealing with Production Control and Works Statistics, was proceeding.

Standards

The Standards Committee were continuing their work of commenting on B.S.I. Draft Specifications, and nominating members to represent the Institution on B.S.I. Technical Committees.

Hazleton Memorial Library

The Library Committee had agreed to co-operate with the Aeronautical Group of the Association of Special Libraries and Information Bureaux in organising a Conference on the theme of "Information and the Production Engineer", to be held in April, 1954. The Conference would be primarily for librarians and information officers, and it is hoped that with the assistance of Institution members, some improvement in library services to production staffs in factories would result.

Applications for Membership and Transfer

Council approved a number of applications for membership and transfer, particulars of which appear on pages 589/590.

Local Section Reports

Council adopted the Local Section Reports, extracts from which appear on pages 590/593.

Obituary

Council recorded with regret the deaths of the following members :—

Members

C. J. Dick; W. P. Kemp; J. Montgomerie; J. D. Mookherjee; H. J. Pound; W. C. Williamson.

Associate Members

J. Benson; H. Jennings; A. J. Mansell; G. D. Newsome; H. E. Timms.

Date of Next Meeting

Thursday, 28th January, 1954, followed by the Annual General Meeting at 4 p.m.

ELECTION OF MEMBERS

29th October, 1953.

ADELAIDE SECTION

TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
R. J. Woodhams

BIRMINGHAM SECTION

AS GRADUATES
G. E. Hayes, T. E. Sadler, P. Coles, L. J. Fielding.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
D. E. Thacker.

BOMBAY SECTION

AS ASSOCIATE MEMBERS
J. M. Jadeja, B. V. Borgaonkar, J. C. Yamdagni.

NEW AFFILIATED FIRM	NEW AFFILIATED REPRESENTATIVES
Caltex (India) Ltd.	J. Kemp-Drysdale, Allan De-Sa.

TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
R. C. Bromley.
FROM GRADUATE TO ASSOCIATE MEMBER
E. G. Fernandes, A. Nath Mukerji.

CALCUTTA SECTION

AS ASSOCIATE MEMBERS
Sukmar Dev, M. A. Latif, M. S. Babrah.
AS GRADUATES
G. N. Advani, B. N. Ganguly.

COVENTRY SECTION

AS GRADUATES
A. Gordon, R. R. Lamb.

DERBY SECTION

AS GRADUATE
P. F. Thorpe.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
J. Carruthers.
FROM GRADUATE TO ASSOCIATE MEMBER
D. Walker.

GLASGOW SECTION

AS ASSOCIATE MEMBERS
A. McCaskie, R. Fairman.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
D. Crawford.

LEICESTER SECTION

CHANGE OF AFFILIATE REPRESENTATIVE

NAME OF AFFILIATED FIRM	NEW AFFILIATE REPRESENTATIVE
The British United Shoe Machinery Co., Leicester.	H. Grewcock.

AS ASSOCIATE MEMBER
W. H. Cullin.
AS GRADUATES
S. I. Sheikh, D. S. Al-Badri.
AS STUDENTS
A. F. Khalifeh, R. E. Thompson, A. F. Todd.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
J. C. Routledge.
FROM GRADUATE TO ASSOCIATE MEMBER
J. G. Oxnam.

LONDON SECTION

AS MEMBER
G. M. Hayward.
AS ASSOCIATE MEMBERS
H. Bailey, J. W. Crofts, E. T. Honeywill, J. R. Palmer, H. G. Rider, H. E. Tickner.
AS ASSOCIATE
D. Cemm.
AS GRADUATES
M. I. Berkman, L. A. Hutchins, J. D. Wiseman W. A. Waller.
AS STUDENTS
K. J. Eagle, H. Fass, S. A. Richardson, J. T. Oliver, G. A. Deague.

NEW AFFILIATE FIRM
NEW AFFILIATE REPRESENTATIVE
The Lapointe Machine Tool Co. Ltd., Watford, Herts. — C. T. Parkin.
TRANSFER
FROM STUDENT TO GRADUATE
F. L. Hiles, R. G. Mitchell.

LUTON SECTION
AS ASSOCIATE MEMBER
R. M. Bold.
AS GRADUATES
R. J. Laskey, D. Critchley.
AS STUDENTS
D. E. Mack, D. J. Green.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
S. F. Wiggins, T. D. Turner.
FROM INTERMEDIATE ASSOCIATE MEMBER TO ASSOCIATE MEMBER
J. Russell.
FROM GRADUATE TO ASSOCIATE MEMBER
I. Calverley.

MANCHESTER SECTION
AS MEMBERS
A. Sewart, B. H. Fogg.
AS ASSOCIATE MEMBERS
P. S. Pickles, G. Bennett.
AS ASSOCIATE
D. H. Broome.
AS GRADUATES
A. Khan, K. McConnell, K. D. Park, R. S. James.
AS STUDENTS
W. P. Davies, S. D. Whitehead.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
T. L. Morton.
FROM GRADUATE TO ASSOCIATE MEMBER
K. Thewlis.

MELBOURNE SECTION
AS ASSOCIATE MEMBER
W. A. Maw.
AS STUDENTS
F. W. Dick, R. G. McColl, S. G. Anderson, H. B. Arndt.

NEW AFFILIATED FIRMS	NEW AFFILIATED REPRESENTATIVES
Roy Burton & Co. L. P/L.	R. Burton, W. E. Bignell, E. H. Taylor.
A. G. Healing, Ltd.	P. G. Frye, L. W. Parker.

TRANSFER
FROM INTERMEDIATE ASSOCIATE MEMBER TO ASSOCIATE MEMBER
F. C. Rooke.

NORTH EASTERN SECTION
TRANSFER
FROM INTERMEDIATE ASSOCIATE MEMBER TO ASSOCIATE MEMBER
J. W. McGowan.

NORTHERN IRELAND SECTION
AS ASSOCIATE MEMBER
T. S. G. Kee.

NOTTINGHAM SECTION
AS ASSOCIATE MEMBER
C. G. Sissons.

OXFORD SECTION
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
K. L. Brookfield.

PETERBOROUGH SUB-SECTION
AS GRADUATE
G. G. Steels.
AS STUDENT
P. T. Green.

PRESTON SECTION
AS MEMBER
A. S. Hawtin.
AS ASSOCIATE MEMBERS
E. A. Fitton, A. Hollon.
AS GRADUATES
G. A. Winterburn, G. Smith.

READING SECTION
AS ASSOCIATE MEMBER
H. T. File.
AS GRADUATE
D. S. Rayfield.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
G. A. T. Groombridge.

ROCHESTER SUB-SECTION
AS STUDENTS
D. B. Brooks, E. G. Tottman, B. E. Thornby.

SHEFFIELD SECTION
AS ASSOCIATE MEMBERS
L. E. Watts, M. D. J. M. Brisby.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
W. J. Costin.

SOUTHERN SECTION
AS GRADUATE MEMBER
J. Brown.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
I. Ballard, H. W. D. Winkworth.

SOUTH AFRICA SECTION
AS ASSOCIATE MEMBER
K. B. Colvin.
AS STUDENT
W. Nelson.

TRANSFER
FROM INTERMEDIATE ASSOCIATE MEMBER ASSOCIATE MEMBER
A. V. Delorme.

SOUTH WALES
AS ASSOCIATE MEMBERS
R. Stoddard, M. E. Taylor.
TRANSFER
FROM ASSOCIATE TO MEMBER
G. E. Bache.

SOUTH ESSEX SUB-SECTION
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
R. Telford.
FROM GRADUATE TO ASSOCIATE MEMBER
A. C. Taylor.

STOKE-ON-TRENT SUB-SECTION
AS STUDENT
W. R. Levitt.

SYDNEY SECTION
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
W. Edelstein, E. G. Horton.
FROM STUDENT TO GRADUATE
J. C. Evans.

WESTERN SECTION
AS ASSOCIATE MEMBER
A. J. Pack.
AS STUDENT
R. Presswood.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
R. W. Travis.

WEST WALES SECTION
AS STUDENT
H. J. Phillips.
AS GRADUATE
F. W. Bevis.

WOLVERHAMPTON SECTION
AS GRADUATES
G. Bates, R. C. Glasbey.
AS STUDENT
J. Marsh.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
A. Bould, G. C. Jones.

YORKSHIRE SECTION
AS ASSOCIATE MEMBER
F. R. Hutchinson.

NO SECTION
AS ASSOCIATE MEMBER
M. P. A. Bouman, P. H. Cooke.

NEW AFFILIATED FIRM	NEW AFFILIATED REPRESENTATIVES
Empresa Nacional de Motores de Aviacion, S.A.	J. B. Danis, M. M. Batlle, J. E. Grau.

EXTRACTS FROM LOCAL SECTION REPORTS

Presented to Council, 29th October, 1953.

Adelaide

At the June meeting the Section Chairman, Mr. J. H. Law, Section Vice-Chairman, Mr. J. M. Steer, and Mr. D. Johnson, of General Motors—Holden Ltd.,, discussed "World Trends in Machine Tools", the speakers taking respectively European, British and American trends. "Industrial Paint Finishing" was the subject of the July meeting, when the speaker was Mr. R. Matthews, Chief Chemist of the Berger Group of Companies.

Mr. S. H. Boyce, B.E., A.M.I.E.(Aust.), gave a talk to the August meeting on "Some Problems in Power Station Planning", outlining the factors which had to be considered in deciding the type, location and capacity of future power stations. "Diecasting Techniques" is the subject set down for the September meeting.

The Sub-Committee working for the inauguration of a Production Engineering Course here have had a conference with the Education Authority, and have now to marshal support from industry and other interested bodies to present a strong case for the immediate commencement of such a course.

Birmingham

The activities of the Birmingham Section have been overshadowed by the death of the Section Honorary Secretary, Mr. A. J. Mansell, who had given such unstinting service to both the Birmingham Section and to the Institution as a whole. A memorial service was held in Birmingham Cathedral on Tuesday, 29th September, when some 250 members, colleagues and friends attended to pay their last respects to the memory of a greatly cherished friend. A memorial fund has been opened in conjunction with the I.I.A. and the I.I.S., the proceeds of which will be devoted to assisting Mrs. Mansell and the children in the difficult period ahead.

On general activities, the incoming Section President has circularised all corporate members soliciting a greater measure of support for all activities and asking for suggestions whereby the impact of the Institution on local industry can be increased. To date some 15 per cent. of the membership has replied and valuable ideas have been forthcoming.

With regard to the activities of the Birmingham Productivity Association formed under the auspices of the British Productivity Council, the Section is fortunate in having three of its leading Committee members, namely Messrs. H. Burke, W. H. Hodgetts and Professor T. U. Matthew, as members of the controlling Committees and playing extremely active roles in this connection.

The first prize awarded by the Institution for the best performance in the Higher National Certificate in Production Engineering throughout the country was won by W. E. Simpson of Birmingham Aluminium Castings, following a sandwich course at the Chance Technical College,

Smethwick. In a pleasant ceremony on Thursday, 17th September, at the College, a case of drawing instruments was presented to Mr. Simpson by the Section President.

The Inaugural Meeting of the Worcester Sub-Section was successfully held at the Star Hotel, Worcester, on 26th September. The President, Mr. W. C. Puckey, and the Chairman of Council, Mr. H. Burke, addressed the meeting. Leading industrialists in the area have promised full support for this new Sub-Section, which will provide for the needs of members living in the Worcester, Kidderminster, Stourport and Bromsgrove areas.

The opening meeting of the current session was held in September when Mr. R. W. Mann gave a stimulating address on "The Ethics of Production".

Finally, the Section is grateful to Mr. B. W. Gould of the Birmingham College of Technology who has agreed to take over the duties of Honorary Secretary of the Section for the ensuing year.

Birmingham Graduate

In order to achieve a record attendance at the Graduate Convention, in addition to the usual circulation, all firms connected with the Institution in the Birmingham, Coventry, Stoke-on-Trent and Wolverhampton areas were asked to send as many delegates as possible. Representatives of the B.B.C. and the National and Technical press were invited to attend.

The Section programme has gone out to all firms on the mailing list together with a letter. It is intended to get Committee members' reports on what happens when these programmes reach their firms.

The programme for the coming session will include a visit to the Farnborough Air display, the annual dance at the Botanical Gardens, and a Christmas Dance and Social at the Billesley Arms Hotel. The monthly club nights are continued as they have helped members to meet on a social and informal basis.

The possibilities of a continental tour and a visit to a London Theatre are being considered.

Calcutta

The Annual General Meeting was held in April and a further Committee Meeting was held in August.

The loss of the Section President, Mr. J. D. Mookherjee, whose sad demise has already been reported in the September Journal, is deeply regretted.

A Section Meeting was called for 10th September at which Mr. J. Warren-Boulton was elected President for the remainder of 1953/54, with Mr. N. N. Sen-Gupta as Hon. Secretary. At this Meeting, Mr. T. R. Gupta gave an interesting talk on "Industrial Management".

Canada

During the past three months there have been no meetings of the Canadian Section.

However, the 1953/54 lecture programme is nearing completion and will commence in October.

Coventry

In addition to a number of day members attending the Summer School at Ashorne Hill, approximately a dozen committee members were present at Mr. Hooper's lecture on the Friday evening, which from all aspects was most enjoyable.

An informal dinner for committee members and their wives was held at Knowle, near Coventry, at which Mr. S. J. Harley was welcomed as Section President for the current session. On behalf of the Section, thanks were expressed to the retiring President, Mr. E. M. Price, for the invaluable work he had done during his two years of office.

Rugby members will be glad to know that it has again been arranged for at least one and possibly two lectures to be held in Rugby during the coming Session.

Coventry Graduate

The past three months have seen a period of intense activity on the part of committee members in preparation for the forthcoming lecture session. On September 15th, the opening meeting, the "Production Panel", proved most successful. Under the very able Chairmanship of Mr. E. W. Hancock, M.B.E., M.I.Prod.E., the exchange of views and opinions between the panel and the members present on the wide range of topics discussed, proved the excellence of this type of meeting.

At the Convention organised by the Birmingham Graduate Section in September, the Coventry Graduate Section was well represented.

Derby

The Section were privileged to have the 1953/54 lecture session opened by the Institution President, Mr. Walter Puckey. An opportunity was taken during the President's visit to entertain to luncheon a number of leading industrialists in the Derby area. Mr. Puckey addressed the guests on the aims, activities and policy of the Institution.

Glasgow

The Section programme for the 1953/54 session has now been completed and the various subjects chosen for lecture meetings should appeal to all members. Two evenings will again be devoted to open discussion and the first will be on "The Selection of Machine Tools".

In September members of the Section visited Dalzell Steel Works, Motherwell, and considerable interest was shown by all attending.

Halifax

During the 1953/54 session, four of the Halifax Section members will read Papers and a topical programme has been arranged which it is expected will interest a good number of members and friends.

In addition, an endeavour will be made to provide adequate transport to enable members to attend the Institution and Regional Meetings to be held in Leeds and Sheffield respectively.

Halifax Graduate

Two works visits have been held and proved to be extremely popular. The first was to Davy United Ltd., makers of heavy steel works plant, and the second to The Park Gate Iron Co. Ltd.

Following the decision of the recent Graduate Conference in Halifax, the Committee elected two delegates to take part in talks on a Regional basis to study the provision of a standard system for preparation of statistics relating to members' attendance at meetings, etc. A similar body is active in the Midland Region, and it is hoped to arrange a meeting to co-ordinate the work of both parties.

The Weekend School, which proved so popular last year, was held again on October 10th and 11th.

Leicester

The Committee record with regret the passing of one of their most valued members, Mr. H. Jennings, who served on the Committee with distinction for some years.

A working party has been set up under the Chairmanship of the President Elect, Mr. J. C. Routledge, in order to gather together information on "Materials Utilisation".

The Section has been honoured for the first time by the receipt of an invitation to the Section President and Secretary to attend the Lord Mayor's Reception.

Mr. L. R. Houghton now represents the Section on the Committee of the Leicester Productivity Council and Mr. N. A. Cullin, the Past President, is the Section Representative on the Leicester College of Technology Engineering Trades Advisory Committee. In addition, Mr. R. M. Evans and Mr. L. S. Pitteway serve on the Research and Education Standing Committees of the Institution.

Lincoln

The loss from the Section Committee of Mr. Howlett of Aveling Barford is regretted. Mr. Howlett, who is a very old member of the Institution, has given valuable help to the Committee. Mr. Earl of the same firm has kindly offered to fill this vacancy.

Members are very grateful to the management of the International Harvester for allowing them to visit their works on Thursday, July 16th.

The inaugural meeting of local branch British Productivity Council was held in Lincoln in June, and Mr. J. R. Bergne-Coupland, past President of the Section, was one of the chief speakers.

London

The Section Committee have arranged a very full lecture programme for the coming Session, which they feel covers both the management and production interests of members. There will be seven meetings in Central London, two at Croydon and three at Brighton.

The Section has been represented at meetings in west, east and north London, organised by the British Productivity Council.

London Graduate

The Section Chairman, together with officers of the Institution, attended a special meeting of junior members and potential junior members in the Rochester area. Talks were given on the requirements for graduateship of the Institution, on the services rendered by the Institution, and how a Graduate Section is organised.

It was decided to limit the number of works visits this Session, but at the same time to arrange them so that each visit provided an opportunity to study a specific aspect of production engineering, and also to meet a specialist officer of the visited company, which has been selected for its particular standing in the subject of special study.

The fourth Weekend School of the Section was held on 12th and 13th September to consider the subject of Work Study. The school was a great success and provided further evidence that this annual event is an established "highlight" of the Section's activities. A report appeared in the November Journal.

Manchester Graduate

The first visit of the 1953/54 Session took place in September, to the works of Kendall and Gent Ltd., machine tool makers. This was followed on September 22nd by a lecture entitled "Diecasting" by Mr. T. Bradshaw.

Early in the month the former Secretary of the Graduate Section, Mr. J. D. Evans, left this country for America where he hopes to take up an appointment in Los Angeles. The Committee agreed that his term of office had been most successful.

Melbourne

The monthly meeting in July took the form of a "quiz night", when a joint meeting was held with the Australian Institute of Metals. A panel of experts from the A.I.M. very capably answered a number of questions concerning metallurgy and heat treatments.

In August, Mr. John Carter, Production Superintendent of The Herald and Weekly Times, Melbourne, spoke on "Newspaper Production", which was followed on August 19th by a visit to the "Herald" establishment. A colour rotagravure section was also visited.

At the meeting in September, a Paper was delivered by Mr. Jack Lonsdale on the production of valves for gases and liquids. Mr. Lonsdale illustrated his lecture with slides showing the types of valves and machinery used for their manufacture.

North Eastern

The Annual General Meeting which concluded last Session's activities was held at Gateshead Technical College in April and was attended by Mr. G. R. Pryor, Vice-Chairman of Council. The Section President, Mr. Elliott, Principal of the Technical College, gave details of the new College buildings, and the meeting was followed by a visit round the engineering block which was nearing completion.

The Section Committee have noted with pleasure that their past President, Mr. R. W. Mann, has been elected Chairman of the British Productivity Council, Newcastle District Committee.

The congratulations of the Committee and of the Section generally have been expressed to Mr. A. Cameron, who last Session won the Institution Award for the best Paper given by a member of the Institution.

Nottingham

The Section's inaugural "Ladies Outing" was held in August when the party were the guests of the Derwent Valley Water Board. The whole afternoon was devoted to inspecting the Board's installations, luncheon and tea being taken in the Marquis of Granby Hotel, Bamford. Afterwards the party drove through some of the most picturesque scenery in Derbyshire.

Two works visits have been held and preparations have been made for an interesting winter programme, including a Dinner and Dance to be held in mid-November.

Oxford

The outstanding event during this quarter was the holding of the Sir Alfred Herbert Paper in the Sheldonian Theatre, in connection with which the Oxford Section Committee were able to render some assistance to the Head Office staff. Many members of the Section, and well-known executives of local undertakings, were present, and it is felt that the publicity resulting from the holding of such an important meeting in Oxford should be reflected in the attendance at Section meetings.

The programme for the 1953/54 Session has now been completed, and will include lectures on a wide variety of subjects such as the production methods used in local industries, technical developments in the field of manufacture, and management. For the convenience of members it has now been decided to hold lectures in a more central hall, and the ballroom of the Randolph Hotel has been chosen as the most suitable to the needs of the Section.

Peterborough Sub-Section

The 1953/54 programme commenced in September with a works visit to Stewart and Lloyds Ltd., at Corby. The limited number of vacancies for this visit were quickly filled, and a most interesting day ensued. Although this is only the second works visit to be organised by this Sub-Section, it is confidently felt that a few carefully selected visits may be included in future programmes.

The first of six lectures which have been arranged for the coming season is entitled "Planning for Production" and is to be given by the Sub-Section Chairman in October. The programme has been arranged to cover a wide range of subjects within the broad field of Production Engineering.

Mr. H. F. Adams has been elected Vice-Chairman of the Sub-Section and has the good wishes of the Committee in his new office.

Preston

Six lectures have been arranged by the Committee for the coming winter Session and it is anticipated that they will be of considerable interest. Cards giving full particulars will be duly circulated.

The Section were very pleased to welcome the team from Manchester Section for the Annual Golf Match which took place at Pleasington, near Blackburn, in August. This event was thoroughly enjoyed by all who took part, and as a result the trophy will remain in Preston Section for the ensuing year. The Social Secretary is making tentative enquiries regarding the Section's Annual Outing and all members will be notified in due course.

Reading

An enjoyable and most interesting visit was made to the Skefko Ball Bearing Company in September. A party of twenty-one members was given a comprehensive tour around two works and Mr. Wright, the Works Manager, answered questions at teatime.

Lectures are held at Reading, with one at Basingstoke, and consideration is being given to the possibility of holding one in the future at Slough.

South Africa

Mr. H. R. Baines delivered a Paper in July entitled "Recent Advances in the Industrial Use of the Microscope" dealing with various types of microscopes. At the meeting held in September, four films were shown, viz.: "Full

Cycle"; "Putting the Turbine to Sea"; "Farnborough 1952"; and "Le Mans 1952".

The subject of the one day Symposium on 11th September, attended by 280 members and guests, was "Work Study", with particular reference to its application to South African industry. Five Papers were read. Mr. V. J. Donnelly delivered a Paper on "Work Study and its Practical Application". Mr. R. H. Arbuckle contributed to the Paper which was further illustrated by a film strip. Mr. H. J. G. Goyns presented Miss Anne Shaw's Paper on "Technique of Time and Motion Study". Dr. G. J. Bos spoke on the "Application of Time Study in a Jobbing Shop". The final Paper entitled "Influence of Work Study in the Technique of Higher Management" was delivered by Mr. J. B. Charles.

The Annual General Meeting and Dinner was held at the Victoria Hotel, Johannesburg, in August, and was attended by some 110 members and guests.

Southern

Arrangements are now well under way for the second Aircraft Conference which is again to be held at Southampton University in December. It is hoped to repeat the success which the Conference enjoyed last year.

The Lecture Session commences this winter with a Joint Meeting with the Institute of Mechanical Engineers and the Southampton Branch of the Royal Aeronautical Society, and a very successful evening is expected.

The lecture entitled "Production Engineering Research with Special Reference to Metal Cutting" will be read by Mr. K. J. B. Wolfe, M.Sc., M.I.Prod.E., F.R.I.C., F.I.M., at the Polygon Hotel, Southampton, in October.

Stoke-on-Trent Sub-Section

An invitation was received from the Chairman of the North Staffordshire Regional Board of the British Productivity Council to attend the inaugural meeting, in order to set up a local productivity committee. As the Chairman was in Algiers at the time of the inaugural meeting, Mr. Petrie attended as his representative. The Chairman has now been elected a member of the Steering Committee for this area.

The Regional Plan has been given much consideration, the final comments being left over until the next meeting of the Committee.

The programme for the year 1953/54 is now completed and the Section looks forward to a very good Session.

Expressions of appreciation have been received by the Hon. Secretary regarding the expeditious replies and technical information given to members by the Librarian, Mrs. P. L. Steane.

Sydney

Mr. J. Hyman, A.M.I.E.(Aust.), presented a Paper entitled "Preventive Maintenance" in June. In July, Mr. C. A. Gladman, M.I.Prod.E., Principal Research Officer, National Standards Laboratory, presented a Paper entitled "Some Observations of Production Engineering Research Overseas". Tungsten carbides has always been an interesting subject to members and in August, Mr. E. E. Rooste, A.M.I.E.(Aust), gave a Paper entitled "The Manufacture of Tungsten Carbides".

In September, Mr. G. P. Taylor, B.S.(Chicago), B.Sc. (Toronto), M.I.Prod.E., Senior Lecturer in Production Engineering, N.S.W. University of Technology, will be presenting a Paper outlining details of various courses now available on the subject of Production Engineering at the University of Technology.

West Wales

The Section is delighted that Mr. C. H. Cuniffe, M.B.E., has eventually accepted the Vice-Presidency for this Session, after years of "undercover" work as founder member and member of the Committee.

The "base-broadening" policy of the Institution has been a guiding principle in examining the many applications for membership, but the utmost discrimination has been exercised in order to maintain the required standard.

The Section Committee have been in communication and exchanged views with a number of other local organisations of allied interest including the Institution of Mechanical Engineers and the British Horological Institute.

Liaison has been maintained with the technical educational authorities, and correspondence has ensued on the establishment of specialised courses and other matters.

The formation of a social sub-committee is under active consideration.

Wolverhampton

The lecture sub-committee have completed an interesting programme for the winter period, which includes the 1953 Sir Alfred Herbert Paper, "The Industrial Applications of Radio Active Materials", to be given by Sir John Cockcroft at the Wolverhampton and Staffordshire Technical College on April 7th, 1954. This is to be a Regional Meeting and a very large attendance is expected.

In line with the suggestion that local Sections should co-operate in the work of the Institution's Research Committee, a Working Party to investigate "Materials Utilisation" is being formed. Mr. A. S. Sault has agreed to act as Chairman and Mr. W. B. Pamment as Secretary. The Graduate Section, who are co-operating with the Senior Section on this project, have nominated Mr. Wiley as a member of the Working Party.

Wolverhampton Graduate

During the quarter under review the Graduate Committee have completed the visits and Lecture Programmes for the 1953/54 Session. The Committee feel that the Lectures chosen cover a wide range of subjects, which will enable members to acquire further knowledge in their studies of the science of Production Engineering.

From past experience in the Graduate Section, the type of subjects chosen should all draw a large attendance. The first lecture was held in September, when a Paper was read by Dr. Jevons, Ph.D., B.Sc., F.R.I.C., F.I.M., on "The Difficulties and Development of Deep Drawing and Pressing".

The Committee have endeavoured to arrange a works visit for each month of the year; the first visit was held in August, when a party of twenty-seven members visited the National Coal Board Hilton Main Colliery Unit and made a tour of the surface and underground workings.

The rest of the visit programme covers a very wide choice of companies including steel works, tyre manufacturers and a fruit canning company. During previous sessions the Graduates have held two dances a year, which have always been both socially and financially successful. This year a joint Dance with the Senior Section has been arranged, which, it is hoped, will be a greater success than ever before.

Yorkshire

The syllabus has been completed for the 1953/54 Session, and the President and Committee hope that members will give meetings every support and attend as many lectures as possible.

The Committee are considering ways and means of helping in the New Building Appeal Fund, and the next month or so will see the result of their efforts.

Yorkshire Graduate

During the quarter under review three Section Committee meetings have been held, the first of which was attended by the Institution Secretary, Mr. Woodford. The Graduate Sections in the Midland Region, i.e. Yorkshire, Halifax, and Sheffield, have agreed on a policy of closer co-operation.

The Section Chairman, Mr. G. Horner, was very pleased to have the opportunity of attending the July meeting of Council. He found this to be very instructive, and was very impressed with the efficient manner in which the governing body of the Institution conducted its affairs.

INSTITUTION NOTES

ANNUAL GENERAL MEETING

The Annual General Meeting will be held on Thursday, 28th January, 1954, at 36, Portman Square, London, W.1, at 4 p.m.

Formal notice of the Meeting will appear in the January issue of the Journal.

THE ANNUAL DINNER
9th October, 1953

The Institution's Annual Dinner, which this year was held in Guildhall, London, by courtesy of The Lord Mayor, was attended by over 600 members and guests.

The principal Address was given by the Right Hon. Viscount Waverley, P.C., G.C.B., G.C.S.I., G.C.I.E., replying to the Toast of "The Guests", proposed by the President, Mr. Walter C. Puckey. (Lord Waverley's Address was published in the November issue of the Journal, together with reports of speeches made by Sir Rowland Smith, and The Lord Mayor of London, Sir Rupert De la Bère, in proposing and replying to the Toast of "The Right Hon. The Lord Mayor, The Sheriffs and The Corporation of London".)

Among the many distinguished guests was Mr. Lincoln Gordon, Chief of the Special Mission of the Mutual Security Administration and Minister for Economic Affairs, U.S. Embassy. Responding to the Toast, "Mutual Security", proposed by Mr. Harold Burke, Chairman of Council, Mr. Gordon said he

Sir Rowland Smith proposing the toast to "The Right Hon. The Lord Mayor, the Sheriffs and The Corporation of London". Seated, next to Sir Rowland, are Sir Godfrey Ince, C.B.E., K.B.E., Permanent Secretary, Ministry of Labour, and the Right Hon. Lord Hurcomb, G.C.B., K.B.E., Chairman, British Transport Commission.

The President, Mr. Walter Puckey, receiving Lord Waverley on arrival at Guildhall.

had been deeply impressed by the attention given to productivity in the United Kingdom, and by the growing recognition in all quarters of the importance of rapid productivity improvement.

Referring to the need for more technological and management education, Mr. Gordon expressed the view that Production Engineers more than any other group in the engineering profession stood at the border line between general management on the one hand, and the more technical and applied sciences on the other.

Stressing the importance of competition, Mr. Gordon suggested that a right attitude towards healthy competition should have a proper place in the consideration of productivity problems.

During the proceedings, the Institution Awards for 1951/52 were presented by the Right Hon. The Lord Mayor, as follows:

Institution Medal for the Best Paper presented by a Non-Member, to Dr. J. D. Jevons, B.Sc., F.R.I.C., for his Paper, "How the Production Engineer can be helped by the Metallurgist".

Institution Medal for the Best Paper presented by a Member to Mr. A. Cameron, A.M.I.Prod.E., for his Paper, "Increased Productivity by Workshop Practice".

Hutchinson Memorial Award for the Best Paper presented by a Graduate to Mr. J. E. Poulter, for his Paper, "Industrial Application of Porous Ceramics".

Institution Prize for Best Performance in the Higher National Certificate in Production Engineering to Mr. W. E. Simpson, Graduate.

A. J. MANSELL MEMORIAL FUND

The Birmingham Section President, Mr. B. G. L. Jackman, wishes to thank all those many members of the Institution who have contributed so generously to the appeal launched in connection with the above Fund.

It is felt that there may still be certain members who are intending to contribute, and to this end, the Institution would like to make it clear that the final closing date for the appeal will be the 31st December, 1953.

MR. JOHN D. FRIER

Mr. John D. Frier, Member, who has now retired from the Headship of the Mechanical Engineering Department of the Technical College, Coventry, will continue his longstanding representation of the A.T.T.I. on the Joint Examinations Board.

MR. G. W. H. NASH

Mr. G. W. H. Nash, Member, has been appointed a Director of Buck & Hickman Ltd. He joined the Company in 1918, and in 1925 he commenced specialising in gearing, which has remained one of his principal interests.

Mr. G. W. H. Nash

For three years Mr. Nash worked for the Ministry of Supply, Machine Tool Control, under Sir Percy Mills, the Controller. Since 1944, he has been in charge of the Company's Tool Department and Works at Watford.

MR. JACK FINLAY

The Australian Sub-Council and the Sydney Section of the Institution have accepted with great regret the resignation through pressure of business of Mr Jack Finlay, Member, from the offices of Hon. Treasurer to the Sub-Council and Hon. Secretary of the Section.

Mr. Finlay devoted much of his time to Institution affairs during his three years of office, and will be greatly missed by those who take part in the administration of the Institution in New South Wales.

His successor as Section Hon. Secretary is Mr. Albert Welsh, Associate Member.

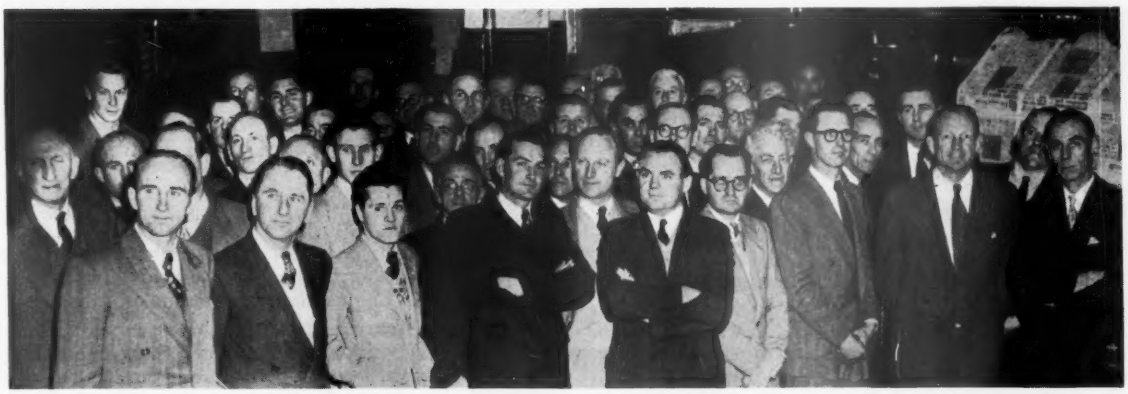
MR. J. BLAKISTON

Mr. J. Blakiston, Member, is now making one of his periodic visits to the Far East, covering Malaya and Bengal, and will return to the United Kingdom early in the New Year.

Norwich Meeting

A photograph taken at the Norwich Sub-Section meeting held on 12th October, 1953, when Mr. Harold Burke, Chairman of Council, gave an address. In the group are (*left to right*) Mr. F. H. S. Heidenstam (Section Hon. Secretary); Mr. Burke; Mr. G. A. Daniell (Section Chairman); Mr. E. N. Farrar (President, Eastern Counties Section); and Mr. K. S. Jewson, a member of the Norwich Sub-Section Committee.

Melbourne Section Visit



This photograph was taken last August, during a visit by members of the Melbourne Section to the offices of "The Melbourne Herald". The Section President, Mr. B. G. Ross, and the Section Hon. Secretary, Mr. C. Pullen, are third and fourth from the right, respectively. The visit followed the reading of a Paper on "Newspaper Production", by Mr. J. Carter, Associate Member, Production Superintendent of The Herald and Weekly Times, Ltd., Melbourne.

This photograph shows the 200 members and guests who attended the highly successful Conference organised by the Birmingham Graduate Section in September, 1953. The theme of the Conference, which was held at the University of Birmingham, was "Engineering Production—Responsibilities and Opportunities", and among the distinguished speakers were Mr. Ian Morrow, C.A., F.C.W.A., Deputy Managing Director of the Brush Group of Companies; Mr. J. Munro Fraser, M.A., Senior Lecturer in the Human Relations Aspects of Management, Birmingham College of Technology; Mr. Walter C. Puckey, President of the Institution; and Sir Cecil Weir, K.C.M.G., K.B.E., immediate Past President of the Institution, who summed up.

OBITUARY

MR. R. W. BEDFORD

The Institution has suffered a heavy loss by the death of Mr. R. W. Bedford, M.B.E., Member, for many years Works Manager and latterly, Contracts Manager, of George Kent Ltd., Luton.

Mr. Bedford was a Founder Member of the Institution, and a past President of the Luton Section, and will long be remembered for his sterling work in the establishment and development of the Institution, particularly in its early days.

NEW APPOINTMENTS

Mr. W. L. Beeby, Member, has relinquished his position as Works Engineer of Metropolitan-Vickers Electrical Co. Ltd., and has been appointed Director of Manufacturing with the Edison Swan Electric Co. Ltd.

Mr. J. W. Bramall, Associate Member, is now employed as Mechanical Superintendent with F. Shepherd & Son Ltd., York.

Mr. E. R. Cash, Associate Member, has relinquished his appointment as Assistant Works Manager with A.E.C. Ltd., Southall, in order to take up a post as Production Manager with A.P.V. Ltd., Wandsworth and Crawley.

Mr. R. F. Eskell, Associate Member, has recently taken an appointment with The African Boiler & Engineering Insurance Co. Ltd., of Johannesburg, as their Resident Engineer and Surveyor, Cape Town.

Mr. E. F. Gilberthorpe, Member, is now Production Manager of the Aircraft Division, The Bristol Aeroplane Co. Ltd., Bristol.

Mr. R. A. Hennery, Associate Member, is now Chief Tool Designer at C.A.V. Ltd., Acton.

Mr. E. H. Holder, Member, has received promotion within the Ministry of Supply, and is now Manager (W), Royal Ordnance Factory, Radway Green.

Mr. D. M. Keir, Member, has joined the staff of the City Engineer, Edinburgh.

Mr. J. D. Perry, Associate Member, has recently been appointed General Manager of Birmidal Developments Ltd., which is associated with Birmid Industries Ltd., Smethwick, a group of companies with which Mr. Perry has been connected for some years.

Mr. H. Glynn Thomas, Associate Member, is now Superintendent Engineer, with the Davy United Engineering Company at the Norsk Jernverk Plant—MO—1—Rana, N. Norway.

Mr. F. W. Tweddell, Associate Member, is now a Lecturer at the Hendon Technical College.

Mr. J. Waugh, Associate Member, has been appointed Northern Representative for Ewbank & Partners Ltd., Engineering Consultants of London.

Mr. W. Wearing, Associate Member, has relinquished his position as Foundry Manager to the Chaseside Engineering Co. Ltd., and has joined the full-time staff of the County Technical College, Wednesbury, Department of Metallurgy.

Mr. D. L. Acharia, Graduate, is now an Inspector of Boilers for the Government of West Bengal.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers. (This list was compiled for press on 25th November, 1953.)

Armstrong Siddeley Motors Ltd.
Associated Electrical Industries Ltd.

R. D. Billing, A.M.I.Prod.E.

A. M. Dent, M.I.Prod.E.
L. S. Doyle, Grad.I.Prod.E.

Electrical & Musical Industries.

Gloster Aircraft Co. Ltd.
D. G. Goscomb, A.M.I.Prod.E.
C. H. Gubbins, A.M.I.Prod.E.

W. T. Hines, A.M.I.Prod.E.
J. N. Hullah, Stud.I.Prod.E.
G. A. Hutcheson, M.I.Prod.E.

A. A. Jocobsen, Grad.I.Prod.E.

P. H. Lee, M.I.Prod.E.

A. M. McFarlane, A.M.I.Prod.E.
R. H. Mead, A.M.I.Prod.E.

National Cash Register Co. (Manufacturing) Ltd.

H. J. Nixon, M.I.Prod.E.

G. R. Pickles, M.I.Prod.E.

A. V. Roe & Co. Ltd.
R. Rowley, A.M.I.Prod.E.

United Steel Companies Ltd.

F. V. Waller, M.I.Prod.E.
G. & J. Weir Ltd.
J. H. Winskill, M.I.Prod.E.

N.P.L. SYMPOSIUM ON ENGINEERING DIMENSIONAL METROLOGY

(Continued on page 572.)

equipped to deal with many important aspects of Mechanical Engineering Research.

The sessions on Wednesday afternoon and Thursday morning were devoted to the subject of Workshop Inspection under the Chairmanship of Mr. S. J. Harley, M.I.Prod.E., and Mr. J. E. Sears respectively. Much of the pioneer work of the N.P.L. Metrology Division was carried out under the supervision of Mr. Sears, who was Superintendent for many years up to 1946. The subjects discussed on Wednesday included the application of gauges in industry and the effects of their wear in use, developments of small bore measurement at N.P.L., optical measurement of turbine blades, and methods of screw thread measurement used in France and Germany On Thursday morning there were Papers on statistical quality control, mechanised inspection, and applications of electronics in metrology.

On Thursday afternoon the delegates divided into two sessions. One session dealt with Pneumatic Gauging under the Chairmanship of Dr. H. Barrell, who succeeds Mr. Rolt as Superintendent of the Metrology Division. Papers on machine tools were discussed in the concurrent session including one by Dr. D. F. Galloway, M.I.Prod.E., Director of P.E.R.A., and others dealing with methods developed at the N.P.L. for testing machine tools.

On Friday, sessions were devoted to Gear Measurement, Education, Small Scale Metrology, Large Scale Metrology and Surface Finish.

Four Papers on Gear Measurement dealt with developments in gear metrology, gear shaving, effects and measurements of errors, and developments in gear testers.

The Papers in the Education section were by Professor H. Wright-Baker and Mr. V. W. Clack of Wandsworth Technical College, and these dealt with education in metrology at University and Technical College level.

The two Papers in the field of Small Scale Metrology dealt with Metrology in the Horological Industry and Small Screw Threads. The subject matter of these Papers was somewhat outside the scale of dimensions with which most engineers normally deal. The same remark applies to the session on Large Scale Metrology, in which the subjects ranged from long co-ordinates for aircraft structures to methods used in the construction of the Harwell BEPO pile. Two of the Papers dealt with the work done on the Continent and in this country on the measurement of large work pieces. Investigations are being made into accuracies of measurement on this scale prior to the extension of the present system of I.S.A. and B.S.I. limits and fits to dimensions over 20 inches (500 mm.).

Surface Finish was discussed under the Chairmanship of Mr. J. E. Baty, M.I.Prod.E., and included Papers on surface finish measurement and the engineering requirements for various grades of finish.

Copies of the Papers had been circulated to delegates in advance and consequently many contributors to the discussion were well armed with supplementary information; the standard of the discussions was generally quite high. The proceedings of the Symposium are to be published in due course by H.M. Stationery Office.

The Metrology Division of the N.P.L. was open to delegates on Saturday morning, 24th October. Several of the authors of Papers had arranged exhibits of equipment which were on show, and the general methods and work of the Division were also open to inspection.

It was generally agreed that the Symposium had been highly successful, and Mr. Rolt and his colleagues are to be congratulated on providing a platform for the exchange of so much valuable information on an international level.

All members of the Institution will wish Mr. Rolt a happy retirement and can be sure that he will be no less active in retirement than during his official career.

K. J. H.

HAZLETON MEMORIAL LIBRARY

Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. During the month of December, full facilities will not be available at the following times :—

Wednesday, 9th December, from 2 p.m. Thursday, 10th December, all day.

REVIEWS

658. INDUSTRIAL ORGANIZATION ; MANAGEMENT

"**Administrative Behaviour : A Study of Decision-Making Processes in Administrative Organization,**" by Herbert A. Simon. *New York, Macmillan,* 1951. 259 *pages.* $4.00.

This book will interest all who wish to study the art of administration and who desire to go deeper into the problems underlying successful management. In the past an administrator relied largely on his natural gifts, his intuition and his previous experience, and very often it would not have been possible for him to put into words the reasons for his actions.

However, reading through chapter after chapter of this book, one realises that the author has been able to find expression for thoughts which in most of us were only latent. The psychological understanding brought to the study of the thoughts, behaviour and reactions of the people who make up an administration is very considerable.

One does, however, feel surprised that greater emphasis has not been given to the importance of leadership, but the book deals admirably with the administrator's responsibility to the Community.

H.A.C.

"**Three Studies in Management**" by Jerome F. Scott and R. P. Lynton. *London, Routledge & Kegan Paul,* 1952. 220 *pages. Diagrams.* 18/-.

This is a report of three field studies undertaken with a view to throwing fresh light on the problems of organisation, communication, control and adaptation. By the serious student of management it may be regarded as a major contribution, at least on this side of the Atlantic, to the post-war thought and knowledge of these topics. To those, however, who believe that managers are born, not made, and in Britain there are many who still belong to this school of thought, much of this book is only commonsense and the remainder so much futility.

But if management is to be taught, since British industry, nationalised or otherwise, cannot hope to fill all its executive positions with born managers, then there is a definite need for a literature which deals with the topics of organisation, etc. A book of this kind is meant for advanced students in these subjects, e.g. practising managers who are giving serious thought to the questions of organisation, etc. There is no doubt that the problem of persuading both sides of industry to accept drastic changes in organisation, etc. is a serious one.

The Appendix on Research Method should be read by all who are contemplating research on management problems. Most books of this description end with a lengthy bibliography, an impressive testimony to the author's scholarship. In Appendix B, Messrs. Scott and Lynton have provided short notes on a select bibliography which act as a guide and encouragement to the reader who desires to pursue these topics further.

D.E.G.

331.12 ORGANIZATION OF DEPARTMENTS

"**Leadership in the Factory**", by John Munro Fraser. *London, Pitman,* 1953. 59 *pages. Illustrated.* 3/-. (*The Supervisor's Guides, No.* 1.)

Leadership, human relations, the social situation at work, these are themes which keep cropping up in management literature. Since the Hawthorne investigations over twenty years ago, we have been aware of their importance, and we have been aware also that the groupings in a factory play a large part in its state of morale. The recent studies of consultation in the informal working groups at Aston Chain and Hook and elsewhere are the latest development in this field, but like so many more they are concerned with the informal and unofficial side of the matter, and not with the ordinary channels of executive and supervisory communication. Little attention has been paid so far to improving the relationships in the official groupings of an organisation, and we are in danger of looking at this "Human Relations" field as something separate from the normal productive working of an industrial company.

The distinctive contribution of this little book is that it deals with the official or formal organisation of a company and considers the leadership of the groupings in which the productive work is done. It has some important points to make about the factory floor situation, and deals with the position of the junior supervisor realistically in the light of present day conditions. If the ideas put forward are sound, then it may point the way to a real restoration of the official chain of control where the actual job is done.

Written primarily for supervisors, it is simple and straightforward in style, and its price is a welcome change from that of some other volumes in its field. For those in higher positions who are interested in the development of management thought, it should provide a stimulating and thought-provoking hour's reading.

A.J.M.

657.47 COST ACCOUNTING

" Studies in Costing ", edited by David Solomons. *London, Sweet & Maxwell,* 1952. 643 *pages.* £1. 15s. 0d.

This important book was edited on behalf of the Association of University Teachers of Accounting by David Solomons, Reader in Accounting in the University of London. It contains 26 articles on various aspects of Costing and it is obvious that each article has been chosen because it is outstandingly good. The quality of thinking throughout the whole book is of a very high order.

Some of the authors are University teachers; others are engaged in industry. It is not practicable in a short review to deal at length with such an amount of valuable work as is contained in this book. Comment will, therefore, be restricted to two of the Papers. The first " Accounting Before the Event " by Sir Charles Renold and the second " Case Study of Production and Cost Control " by C. J. Peters.

After leaving school in this country Sir Charles Renold took a degree in Engineering in U.S.A. and then joined Hans Renold Limited, a company founded by his father. Sir Charles is now Chairman of the Renold and Coventry Chain Company Limited. He opens his Paper by saying that in it he is concerned with accounts " . . . not as an accountant, but as a manager of an industrial enterprise, seeking guidance from them in the formulation of management policy and the framing of management decisions ". The Paper contains a lucid and sound exposition of the requirements which must be met by an accounting and costing organisation which is to be of maximum value to management. It also outlines some aspects of the business of the Renold and Coventry Chain Company Limited and explains how the accounting and costing problems were met. At the end of the Paper, there are more than 30 pages of detailed appendices giving examples of various accounting and budgetary control statements used in the company.

Mr. C. J. Peters is an American production engineer and his article is another excellent case study. It contains a description of the methods of control used by Mr. Peters in the Iron Fireman Manufacturing Company of Portland, Oregon, U.S.A. It gives specimens of forms used for Production Control, Shop Loading, Cost Control and so on. Mr. Peters ends his Paper by saying:—

" . . . . The use of the tools of production control, as well as cost control and budgetary control, when properly applied has become what might be called a true art and science. By controlling causes, we control effects. When we can control effects, we can predict a result. When we have done this we have created a new science in modern industry and management . . . . . "

This book can be recommended to all who are concerned with the deeper aspects of costing and industrial management. H.H.N.

Organisation for European Economic Co-operation—*Technical Assistance Mission No. 50.* Cost Accounting and Productivity: The Use and Practice of Cost Accounting in the U.S.A. Report by a group of European experts. *Paris, O.E.E.C.,* 1952. 125 *pages.* 4/6d.

Cost Accounting and Productivity is a report by experts of O.E.E.C. who formed a Mission to the U.S.A. to study the service which American accountants give to industry.

The report commences with the general outlook and development of American management, and deals with the detail work of management at executive level and the division of responsibility for policy making and operating functions.

A brief comparison is given between the cost practices of Europe and America, but it does not attempt to define a typical cost system of either Continent.

The general principles and procedure for budgeting are concisely dealt with followed by a chapter on standard costs. These are dealt with by definition and purpose with views as to methods of setting standards and the control of variants, this latter being more within the control of shop management than at higher executive level.

A final chapter on reports and their value to top management with views on method of presentation is followed by methods of training for management, conclusions and recommendations.

The annexes cover tabulated information on firms and institutions visited, and individual examples of one or other of the phases of the report as applied to a particular firm or industry.

The report is a general summary of views on cost accountancy, many of which will be shared by the vast numbers of executives from this country who have visited their colleagues in comparable industries in the U.S.A. D.H.M.

PAPERS RECEIVED

1952: **" Modern Finishing Processes "** by K. W. Abineri.
1954: **" Automatics—Single and Multi Spindle Screw Machines "** by R. Jenks.
1955: **" Some American Techniques of Cost Control "** by K. Teale and G. W. Williamson.
1956: **" Metal Finishing "** by H. Silman.
1958: **" History, Development and Some Methods of Rolls-Royce Ltd "** by T. Broome.
1959: **" American Automobile Production Methods "** by D. Burgess.
1960: **" Some Problems Associated with the Manufacture of Large Turbo-Alternators "** by J. W. Taylor and J. Henderson.
1961: **" An Introduction to the Development of Machine Tools "** by G. Wilding.
1963: **" Further Thoughts "** by E. Gordon England.
1964: **" Manual Skills and Industrial Productivity "** by W. D. Seymour.
1967: **" Materials Handling "** by E. Williamson.

OTHER ADDITIONS

674 WOOD INDUSTRY ; WOODWORKING MACHINERY

Zandstra, K. A. **" Wood Glueing in Industry."** *London, Society of Engineers (Inc.),* 1952. pp. 47-72. *Illustrated. Diagrams.*

677 TEXTILE INDUSTRY

British Productivity Council, London. **" Cotton Faces the Future : A Review of Progress in the Spinning and Doubling Sections of the Industry."** *London, the Council,* 1952. 16 *pages typescript.*

Silverman, H. A. ed. **" Studies in Industrial Organisation : the Textile and Clothing Industries."** *London, Methuen & Co. Ltd.,* 1946. 362 *pages.* £1. 0s. 0d. (Nuffield College—Social Reconstruction Survey; ed. by G. D. H. Cole and A. D. Lindsay.)

Textile Institute, Manchester. **" Yearbook . . . and Library Catalogue. No. 5, 1952-3."** *Manchester, the Institute,* 1953. pp. 142, M166.

678 RUBBER

British Rubber Development Board, London. **" Natural Rubber Latex and its Applications."** *London, the Board,* 1952. 2 *parts. Illustrated. Diagrams. No.* 1, Stevens, H. P. **" An Introduction to its Origin, Properties and Manufacture."** 1952. 72 *pages. No.* 2, Blow, C. M., and Stokes, S. C. **" Latex Casting."** 1952. 39 *pages.*

621 MECHANICAL ENGINEERING

Science Museum, London. **" Historic Books on Machines . . . Book Exhibitions Number Two, Catalogue."** *London, H.M.S.O.,* 1953. 28 *pages.* 1/6.

The Council of the Institution

1953/54

President
Walter C. Puckey

Chairman of Council
H. Burke

Vice-Chairman of Council
G. R. Pryor

Past Presidents
Major-General K. C. Appleyard, C.B.E., The Rt. Hon. Viscount Nuffield, G.B.E., J. D. Scaife, Dr. H. Schofield, C.B.E.

Vice-Presidents
T. Fraser, C.B.E., E. W. Hancock, M.B.E., J. E. Hill.

Sub-Council Presidents
AUSTRALIAN SUB-COUNCIL—Sir John Storey
SOUTH AFRICAN SUB-COUNCIL—W. G. Gillespie

Section Presidents

J. H. Law .... *Adelaide*
B. G. L. Jackman ...... *Birmingham*
E. H. Y. Burden .... *Bombay*
J. Warren-Boulton .... *Calcutta*
C. J. Luby .... *Canada*
Capt. F. W. Spencer .... *Cornwall*
S. J. Harley .... *Coventry*
A. F. Kelley .... *Derby*
J. Butler .... *Dundee*
E. N. Farrar .... *E. Counties*
Dr. A. F. Muir .... *Edinburgh*
W. P. Kirkwood . ... *Glasgow*
J. Blakiston .... *Halifax*
S. Radcliffe .... *Leicester*
E. Burgess .... *Lincoln*
J. O. Knowles .... *Liverpool*
R. E. Leakey .... *London*
W. E. Park .... *Luton*
H. Spencer Smith .... *Manchester*
B. G. Ross .... *Melbourne*
J. A. Holmes .... *New Zealand*
J. Henderson .... *North Eastern*
J. Ringland .... *N. Ireland*
E. Barrs .... *Nottingham*
L. P. Coombes .... *Oxford*
H. Kirkman .... *Preston*
F. V. Waller .... *Reading*
J. H. Hartley .... *Sheffield*
H. Bainbridge .... *Shrewsbury*
W. G. Gillespie .... *South Africa*
F. C. Cooke .... *Southern*
C. L. King .... *S. Wales*
J. E. Strick .... *Sydney*
E. F. Gilberthorpe .... *Western*
Capt. Leighton Davies, C.B.E. .... *W. Wales*
R. Beasley .... *Wolverhampton*
S. G. Haithwaite .... *Yorkshire*

Additional Section Representatives

E. Percy Edwards ...... *Birmingham*
H. W. Harper, M.B.E. ... *Birmingham*
C. J. Swain .... *Coventry*
H. Gardner .... *Glasgow*
A. P. Peat .... *Leicester*
R. Kirchner .... *London*
F. G. S. English .... *London*
R. K. Allan .... *Luton*
R. H. S. Turner .... *Manchester*
H. G. Gregory .... *Manchester*
T. McCulloch .... *N. Eastern*
E. G. Eaton .... *Preston*
E. Levesley .... *Sheffield*
R. S. Brown .... *Western*
G. W. Wright .... *Western*
C. L. Old .... *Wolverhampton*
H. Tomlinson .... *Wolverhampton*
F. T. Nurrish, M.B.E. ...... *Yorkshire*

Chairmen of Standing Committees
W. J. T. Dimmock B. H. Dyson C. M. Holloway C. L. Old S. A. J. Parsons M. Seaman
The Rt. Hon. Lord Sempill, A.F.C.

Elected Members
A. J. Aiers H. W. Bowen, O.B.E. R. M. Buckle J. E. Burnett R. S. Clark W. Core B. H. Dyson
P. G. Garside B. G. L. Jackman Prof. T. U. Matthew A. L. Stuchbery H. J. Swift, O.B.E.

Overseas Sub-Councils

AUSTRALIA

President
Sir John Storey

Chairman
J. E. Strick

Vice-Chairman
B. G. Ross

Elected Members
R. W. Deutsher S. Downie N. Eaton N. Esserman W. M. B. Fowler W. Gwinnett W. L. Hemer E. Herbert
J. H. Law J. O. Ogden C. Pullen H. G. Sutton A. Welsh L. W. Worthington

SOUTH AFRICA

President
W. G. Gillespie

Vice-President
H. J. G. Goyns

Past Presidents
B. Anderson R. H. Arbuckle L. H. L. Badham G. Godfrey J. Henry D. Lion-Cachet J. Renwick A. C. Wotherspoon

Elected Members
G. T. Chawner D. N. S. Clare V. J. S. Donnelly C. O. Doehring E. Hamm A. P. R. Hodge D. A. Petrie
G. M. Pratley P. L. Ward H. H. Waters

SUB-SECTION CHAIRMEN

.... *Doncaster*
L. E. Broome .... *Gloucester*
G. A. Daniell .... *Norwich*
A. P. Peat .... *Peterborough*
J. J. Gleeson .... *Rochester*
R. R. Kenderdine .... *South Essex*
H. Porter .... *Stoke-on-Trent*
B. G. L. Jackman .... *Worcester*

Secretary of the Institution
W. F. S. Woodford

SECTION HONORARY SECRETARIES

AUSTRALIA

Adelaide (South Australia) ...	W. L. Hemer, 6 Bedford Street, Brooklyn Park, South Australia.
Melbourne (Victoria Australia) ...	R. W. Deutscher, Bank House, 11 Bank Place, Melbourne, C.I, Victoria, Australia.
Sydney (N. S. Wales)	A. Welsh, Room 802, 16 Barrack Street, Sydney, Australia

CANADA

Canada	T. H. Beard, 114 Glendale Avenue, North York, Toronto.

INDIA

Bombay	Mrs. S. G. Barbet (Acting), Top Flat, 25 1st Pasta Lane, Colaba, Bombay, 5.
Calcutta	N. N. Sen Gupta, 110 Surrendra Nath, Ban Jeri Road, Calcutta 13.

NEW ZEALAND

New Zealand	H. R. Holmes, Pah Road, Papatoetoe, Auckland.

SOUTH AFRICA

South Africa	The Secretaries, Institution of Production Engineers, Barclays Bank Buildings, Corner Commissioner and Harrison Streets, Johannesburg.

UNITED KINGDOM

Birmingham	B. W. Gould, 3 Bradbury Road, Olton, Birmingham.
Cornwall	F. G. Hawke, 17 Church Road, Pool, Redruth, Cornwall.
Coventry	R. F. Eaton, 232 Longfellow Road, Coventry.
Derby	A. Short, 244 Uttoxeter Road, Mickleover, Derby.
Doncaster Sub-Section	W. H. Edwards-Smith, 32 Westmoreland Street, Balby, Doncaster.
Dundee	K. Fairweather, c/o D. Morrison, 13 Kerrsview Terrace, Dundee, Angus.
Eastern Counties	A. B. Brook, Davey Paxman & Co. Ltd., Britannia Works, Colchester.
Edinburgh	A. Atkinson, Priory House, South Queensferry, West Lothian.
Glasgow	W. H. Marley, G. & J. Weir, Ltd., Coltness Foundries, Newmains Lanarks.
Gloucester & District	P. C. Bradshaw, Dunsworth Cottage, Norton, Glos.
Halifax	Miss N. E. Bottom (Acting), Hopkinsons Ltd., Huddersfield.
Leicester & District	A. T. Vasey (Acting), c/o Wadkin Ltd., Green Lane Works, Leicester.
Lincoln	H. Wright, 101 Longdales Road, Lincoln.
Liverpool	L. C. Jarman, 17 Cambridge Road, Prenton, Birkenhead.
London	R. Hutcheson, Machine Shop Magazine, Dorset House, Stamford St., London, S.E.1.
Luton	J. F. W. Galyer, Engr. Dept., Luton & South Beds College of Further Education, Park Square, Luton.
Manchester	G. R. Parker, 722 Ripponden Road, Moorside, Oldham.
North Eastern	G. D. Robinson, 27 Holme Avenue, Newcastle-on-Tyne 6.
Northern Ireland	W. G. Wyman, "Linden Lea", Cultra, Co. Down, N. Ireland.
Norwich Sub-Section	F. H. S. Heidenstam, 33 Cecil Road, Norwich.
Nottingham	C. N. T. Manfull, Chellaston House, Thurgarton Street, Nottingham.
Oxford	M. J. Inston, 53 Rymers Lane, Cowley, Oxford.
Peterborough Sub-Section	E. G. Perrett, 165 St. Pauls Road, Peterborough.
Preston	F. T. Graham, 254 Whalley New Road, Blackburn, Lancs.
Reading	R. W. H. Mark, "The Beeches", 41 Reading Road, Woodley, Berks.
Rochester & District Sub-Section ...	W. G. Clements, 101 Featherby Road, Gillingham, Kent.
Sheffield	E. Levesley, The English Steel Corporation Ltd., Sheffield.
Shrewsbury	J. A. Francis, "Meole Meads", Bank Drive, Longden Road, Shrewsbury.
Southern	J. W. Taylor, 44 Deacon Road, Bitterne, Southampton.
S. Essex Sub-Section	P. H. W. Everitt, 6 Hillcrest Road, Loughton, Essex.
South Wales & Mon.	W. D. Porter, 49 Kyle Avenue, Rhiwbina, Cardiff.
Stoke-on-Trent Sub-Section ...	R. Rowley, North Staffordshire Technical College, Stoke-on-Trent.
Western	A. Eustace, 19 Ferndale Road, Northville, Bristol 7.
West Wales	H. P. Sanderson, I.C.I. Ltd. (Metals Division), Waunarlwydd, Nr. Swansea.
Wolverhampton	W. B. Pamment, Wolverhampton and Staffordshire Technical College, Wolverhampton.
Worcester Sub-Section	R. Wheeler, Old Farm House, Parish Hill, Bournheath, near Bromsgrove, Worcs.
Yorkshire	J. L. Townend, 26 Moor Allerton Drive, Street Lane, Leeds 7.

CORRESPONDING MEMBER IN THE MIDDLE EAST

J. Merkine, 45 Arlozoroff Street, Ramat-Gan, Israel.

GRADUATE SECTION HONORARY SECRETARIES

Birmingham	W. Silberbach, 44 Linwood Road, Handsworth, Birmingham 21.
Coventry	L. B. Rutter, 1 The Countess's Croft, Cheylesmore, Coventry.
Halifax	C. W. Overin, 353 Whitehall Road, Westfield, Wyke, nr. Bradford.
Liverpool	T. L. Henthorne, 306 Robins Lane, Sutton, St. Helens.
London	L. J. Saunders, 12 Woodfield Road, Ealing, London, W.5.
Luton	F. G. Ethelston, c/o 106 Argyll Avenue, Luton, Beds.
Manchester	D. Allott, 47 Williams Crescent, Chadderton, Nr. Oldham, Lancs.
North Eastern	R. F. Loebl, 32 Deneside Avenue, Low Fell, Gateshead-on-Tyne 9.
Sheffield	G. Shaw, C. & J. Hampton Ltd., Sheffield 2.
Western	C. H. Spearing, Severn View, Easter Compton, nr. Bristol.
Wolverhampton	W. L. Pace, "Linden", 10 Ezekiel Lane, Short Heath, Willenhall, Staffs.
Yorkshire	G. C. Wadsworth, "Beechville", Leeds Road, Scholes, Leeds.

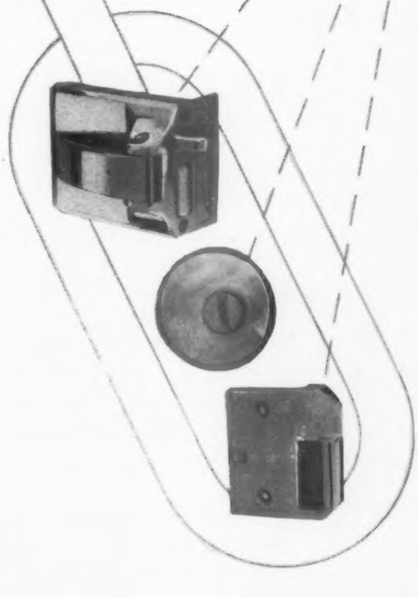
JOURNAL CONTENTS

VOL. 32, 1953.

SUBJECT INDEX to PAPERS PUBLISHED JANUARY/DECEMBER 1953

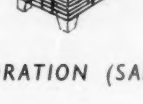
The famous Ingersoll lock, all parts of which are die cast in MAZAK, is a masterpiece of design and manufacture and it relies on the toughness of MAZAK for its great strength.

DIE CAST SECURITY



MAZAK which is based on zinc of 99·99+% purity has a high tensile and impact strength, making it particularly suitable for components that must withstand severe shock and continuous wear as in the case of this modern lock.

MAZAK

Now supplied in  *1 ton pallets to ensure safety and ease of handling*

IMPERIAL SMELTING

U.K. MEMBER OF THE CONSOLIDATED ZINC CORPORATION LIMITED

IMPERIAL SMELTING CORPORATION (SALES) LIMITED · 37 DOVER STREET · LONDON · W.1

A MARBAIX ANNOUNCEMENT

AUTOMATIC PRODUCTION

Bore-to-Bore sizing with

BARNESDRIL

PLUGMATIC HONING MACHINES

HOLE BARNESDRIL FINISHING

The Complete
HONING SERVICE!
MACHINES, TOOLS,
AND ACCESSORIES

BARNESDRIL

SALES AND SERVICE ENGINEERS:

GASTON · E · MARBAIX Ltd

DEVONSHIRE HOUSE · VICARAGE CRESCENT
BATTERSEA · LONDON · S·W·11

'Hi! You can't use a hot saw for sawing bone!'

You'd be surprised at the things people do that they shouldn't with circular hot saws

Few of our customers achieve the error indicated in the sketch, but many of them do not take the same care with a circular saw as they would with a lathe-tool or a chisel. If you want to know how to get the best work out of a circular hot saw for metals, write for our hot saw leaflet, and remember that we make circular hot saws in various sizes and gauges, and with various shapes and pitches, all of them to suit requirements.

We also make circular cold saws, circular friction discs, and other types of saws.

Write for Publication No. 46, using coupon.

To EDGAR ALLEN & Co. Ltd.
SHEFFIED, 9.
Please post Publication No. 46 to

Name ....

Firm ....

Address ....

.... I.P.E.

EDGAR ALLEN & CO. LIMITED.
IMPERIAL STEEL WORKS:- SHEFFIELD.9

TELEPHONE: SHEFFIELD 41054. TELEGRAMS: ALLEN, SHEFFIELD 9

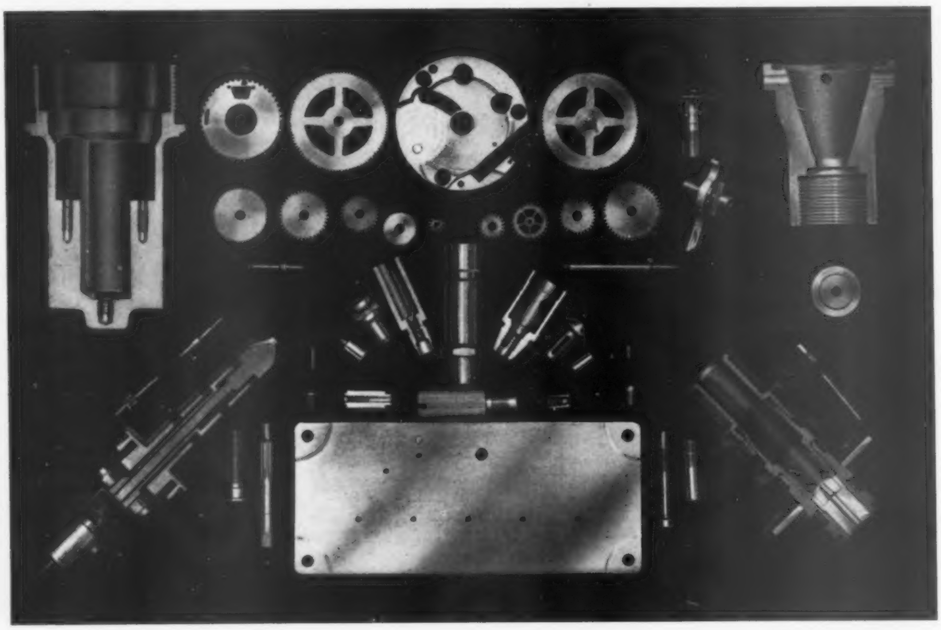
BRAY

ACCESSORIES — LIMITED

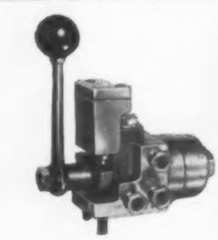
LEICESTER PLACE, LEEDS 2.

Tel: 20981/9

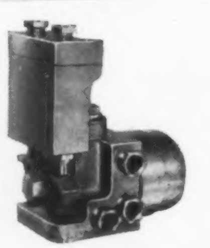
Grams: "BRAYACS LEEDS 2"



MASS PRODUCTION OF PRECISION COMPONENTS & ASSEMBLIES TO FINE TOLERANCES BY NON-SELECTIVE METHODS



Semi-automatic control valve



Fully automatic control valve

Foot Operated valve

For full information write for a copy of our latest catalogue.

TECHNICAL DATA FOR DESIGNERS & WORKS ENGINEERS

Valves

FOR PNEUMATIC CONTROL

Valves are the heart of Pneumatic Control systems and Lang Pneumatic Ltd., have paid particular attention to long service with minimum maintenance. LANG PNEUMATIC valves are all of the slide valve type and are readily convertible from hand to foot, semi or fully automatic control. In combination with impulse solenoid or unloader valves an unlimited variety of automatic or relay sequences can be obtained.

Quality, Service & Quick Delivery

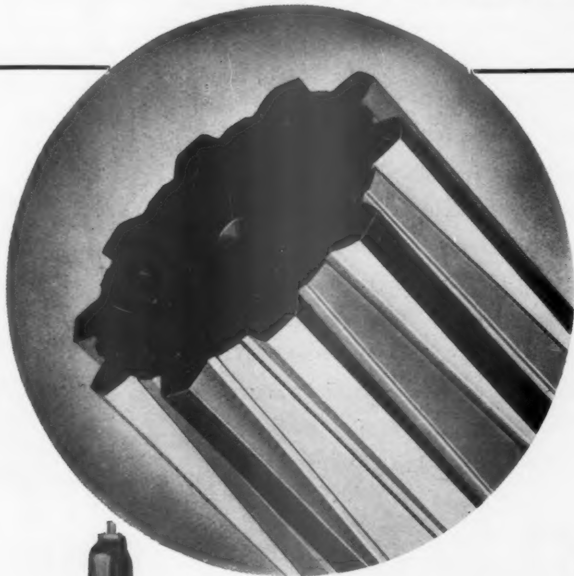
LANG PNEUMATIC *Limited*

VICTORY WORKS, BIRMINGHAM RD, WOLVERHAMPTON

Tel. 25221/2/3

another **BARBER-COLMAN** *development*

THE TAPER CORE SPLINE



B-C MODEL 16-11 HOBBING MACHINE
Although designed primarily for hobbing taper splines on shafts, this machine may also be used for general purpose hobbing.

It is the ideal machine for the manufacturer who desires to improve his product by applying taper splines, eliminating the necessity of buying a special machine which could otherwise not be used for general work.

Involute or straight-sided **TAPER CORE** keys for

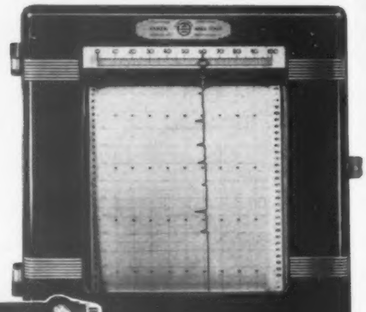
- Greater strength.
- Metal-to-Metal contact.
- Accurate location of Mating parts.
- Greatest security under reciprocating stresses.
- Provides greater area of key contact.
- Saves time and work in assembling a product.
- Eliminates chance key failure.
- Mating parts produced simply by broaching a tapered reamed hole.

BARBER & COLMAN LTD. MARSLAND ROAD, BROOKLANDS, MANCHESTER

Telephone: SALE 2277 (3 lines) Telegrams: "BARCOL", SALE

BURGESS MICRO SWITCHES

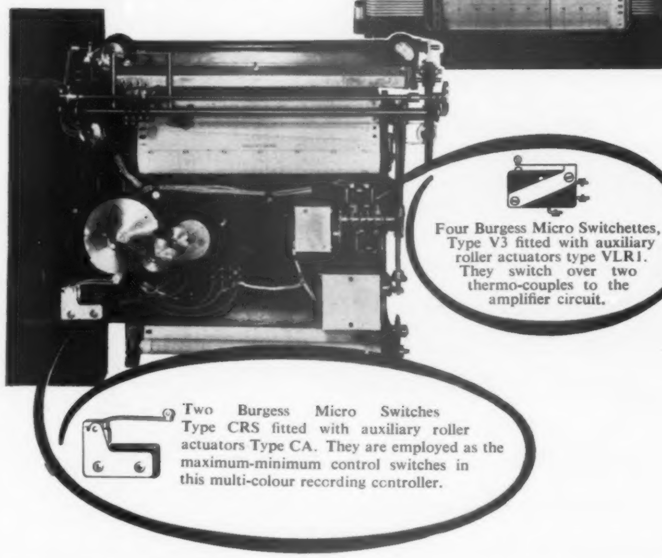
Industry's Automatic Choice



THE ETHER "WIDE STRIP" TYPE WSP/E ELECTRONICALLY-OPERATED POTENTIOMETER

Ether Ltd., use Burgess Micro Switches for electrical control in this and their other high quality products because—like all manufacturers of repute—they believe in having the best component equipment obtainable.

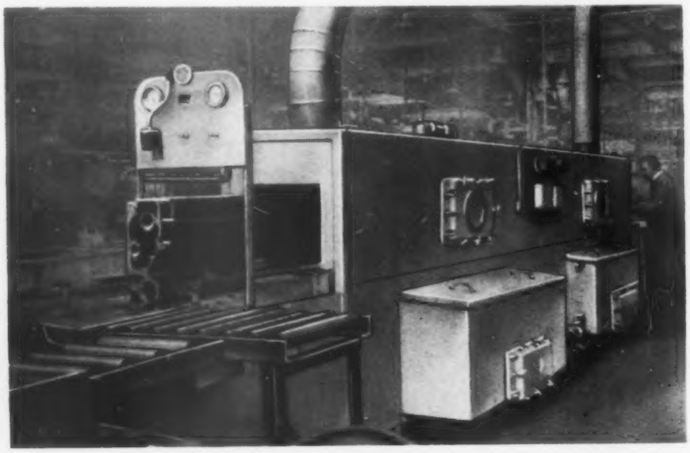
In your products too there are probably many points where a Burgess Micro Switch could give you similar trouble-free service; if so, there is almost certainly a suitable model for your application described in our Catalogue No. 50/15—please write for a copy.



BURGESS

MICRO-SWITCHES

Burgess Products Company Limited,
Micro-Switch Division,
Dukes Way, Team Valley, Gateshead 11.
Telephone: Low Fell 75322/3.



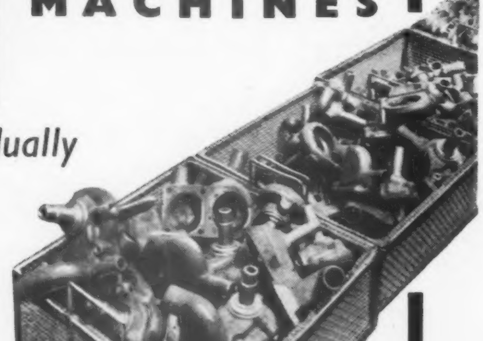
Bratby

INDUSTRIAL CLEANING MACHINES

Each cleaning problem studied individually

THIS ILLUSTRATION SHOWS A MACHINE CLEANING CRANK CASES IN THE PRODUCTION LINE. IT IS EQUALLY CAPABLE OF CLEANING SMALL PARTS IN BASKETS.

Bratby & Hinchliffe Ltd.



SOLE AGENTS FOR GREAT BRITAIN:

GEO. H. HALES MACHINE TOOL CO. LTD.

VICTOR HOUSE · 1, BAKER STREET · LONDON, W.1.

Designed and manufactured by

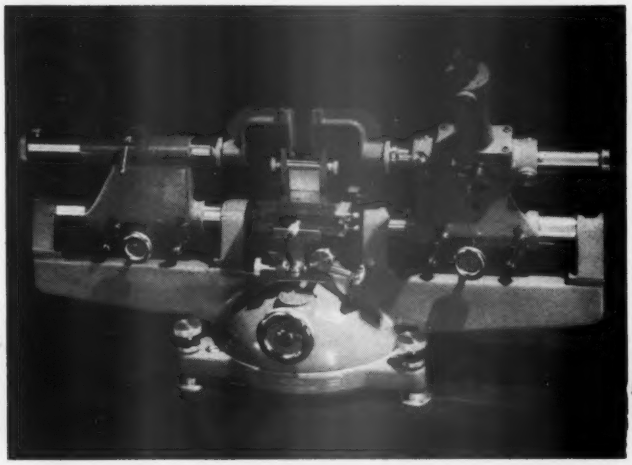
BRATBY & HINCHLIFFE LTD., SANDFORD STREET, ANCOATS, MANCHESTER 4.


KEARNEY & TRECKER
MILWAUKEE
Milling Machines
Plain, Universal and Vertical Models.
Table sizes 46" x 12" to 74" x 15½".
Manufactured in England
by C.V.A. Jigs, Moulds and Tools, Ltd.
E. H. JONES
(MACHINE TOOLS) LTD.
GARANTOOLS HOUSE, PORTSLADE
BRIGHTON - - - SUSSEX
Telephone: HOVE 47253 Telegrams: Garantools, Portslade
LONDON · BIRMINGHAM · EDINBURGH · MANCHESTER · BRISTOL

RATHBONE


PRECISE TOOLS AT MAXIMUM
PRODUCTION RATES ....
HARDIMOND LTD
COVENTRY USE ...
PRECIMAX
GRINDERS
By courtesy of Hardimond Ltd., Coventry, makers of high class standard and special small tools and tooling equipment, we show one of our PRECIMAX universal grinders finishing a core drill to limits of within 0.00025 in.
If your work calls for the highest possible finish and accuracy, at maximum production rates, there is a PRECIMAX grinder to meet your needs.
Ask for further details.
JOHN LUND LTD.
CROSSHILLS · KEIGHLEY YORKS


CLINOMETER



And now...

The HYDRAULIC MACHINE VICE

The SANDERS 'Hydrovice'

- POWERFUL AND TROUBLE FREE
- SELF-CONTAINED . . . NO EXTERNAL POWER SUPPLY NEEDED

The HYDROVICE is powered by a hand-operated pump built into the body of the vice, given pressures up to approximately 14,000lb. Operation is exceptionally rapid, gripping and releasing of work being five times faster than with normal types. Operation is by simple up and down movement of a removable lever having right or left hand operation.

SPECIFICATION

Width of jaws ...	5in.	Overall height ...	$4\frac{7}{8}$in.
Depth of jaws ...	$1\frac{11}{16}$in.	Overall length ...	15in.
Maximum opening ...	3in.	Overall width ...	$8\frac{1}{4}$in.

Pressure up to 14,000lb.

A POWERFUL GRIP AND IMMEDIATE RELEASE WITHOUT EFFORT. EX. STOCK

STANDWELL EQUIPMENT CO., LTD. WORPLE MEWS, WORPLE RD., LONDON, S.W.19 Telephone: WIMBLEDON 6414

For your Milling, Drilling & Grinding Machine

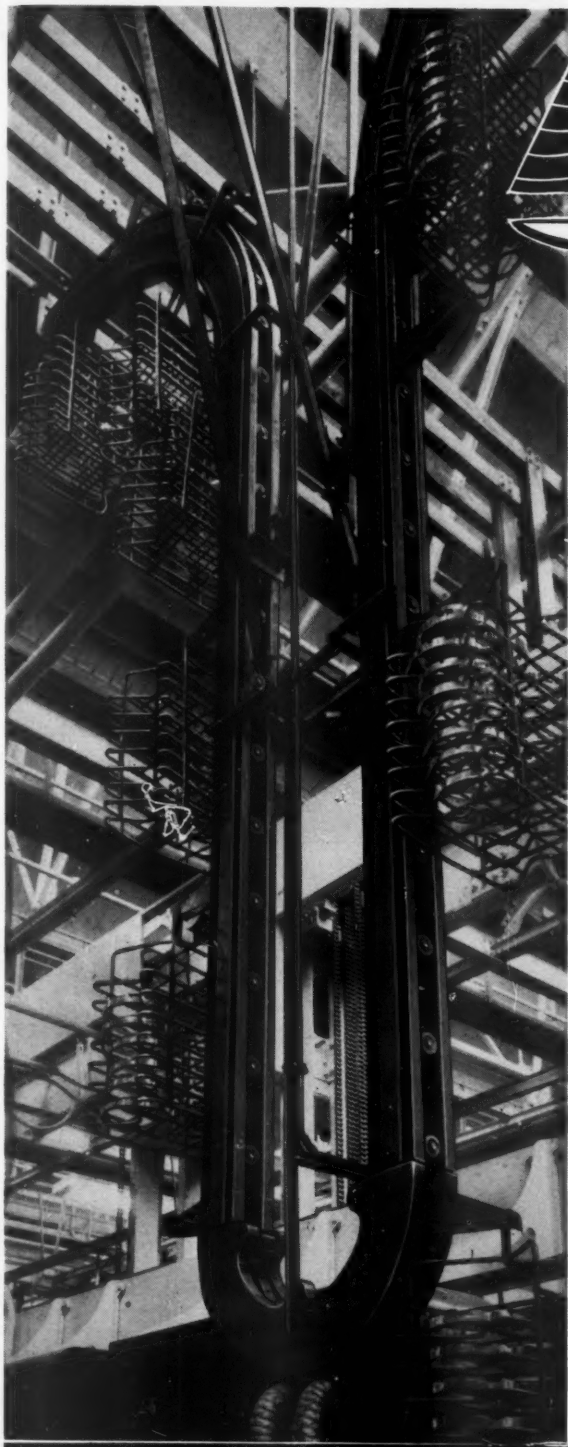
'CENTEC' AUTO-PNEUMATIC INDEXING TABLE

Foot valve operated or automatically synchronised with table movement of machine!

For rapid loading of a large number of small components and for milling of multiple faces on the same component.
Indexing can be foot-operated or automatically synchronised with the table movement.
The table is automatically locked in each indexing position and does not become unlocked in case of air line failure.
A unique feature of this indexing table is that 2, 3, 4, 6 and 12 divisions, i.e., 180°, 120°, 90°, 60°, 30°, indexing can be arranged by merely pressing a button without any change of Index Plates.

Approximate dimensions:
Table—6in.
Overall Length—15in.
Overall Height—4in.
Overall Width—$7\frac{7}{8}$in.

CENTRAL TOOL & EQUIPMENT CO. LTD., CENTEC WORKS, HEMEL HEMPSTEAD, HERTS. *Boxmoor 584-5-6*



INDEX TO ADVERTISEMENTS

All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd.
Crown House, 143-147, Regent Street, London, W.1. Phone: Regent 3891.
Printed by Maxwell, Love & Co. Ltd., White Lion Street, London, N.1.

RNE.

ID11